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Subject: Draft Phase 1 Perchlorate Treatability Study Report

Project Number: 39860

Attached is your copy of the *Draft Phase I Treatability Study Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin*. If you have any questions, please call John Catts at (415) 899-8825 or Matt McCullough at (949) 260-1800.

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DRAFT
Phase 1 Treatability Study Draft Report
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Engineering and Environmental Services

HLA

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Perchlorate in Groundwater
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San Gabriel Basin

Prepared for

Baldwin Park Operable Unit Steering Committee

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CONTENTS

TABLES

PLATES

APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

BOD	Biological Oxygen Demand
BPOU	Baldwin Park Operable Unit
BPOUSC	Baldwin Park Operable Unit Steering Committee
COD	Chemical Oxygen Demand
DHS	Department of Health Services
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
GAC/FB	Granular Activated Carbon/Fluidized Bed
MPN	Most Probable Number
MWD	Metropolitan Water District of Southern California
ORP	Oxidation-Reduction Potential
RfD	Reference Dose
TVMWD	Three Valleys Municipal Water District
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

The purpose of this Phase 1 Treatability Study was to develop a biological treatment technology for perchlorate that could become part of the Baldwin Park Operable Unit Steering Committee (BPOUSC) Consensus Project for remediating various plumes in groundwater in the cities of Azusa and Baldwin Park. The study utilized a biological reduction process using a fixed-film bioreactor. The fixed film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB).

The study was successful and all the study objectives were accomplished:

- The GAC/FB technology successfully treated groundwater with perchlorate concentrations representative of that anticipated in the San Gabriel Basin.
- The GAC/FB technology successfully treated groundwater with nitrate concentrations representative of that anticipated in the San Gabriel Basin to less than the laboratory detection limit of 0.1 mg/L.
- The GAC/FB technology produced an effluent concentration of less than the laboratory detection limit of 4 μg/L, which is less than the DHS provisional action level of 18 μg/L.
- This treatability study demonstrated the effectiveness of a different source of microorganisms; however, disinfection of the effluent will be necessary to ensure that potable water quality standards are met.
- The study demonstrated that with disinfection and filtration, the water produced from the intended treatment train will meet potable standards.

The study also determined and supported development of a number of operational parameters that will be useful in designing a larger system such as the organic substrate addition rate, nutrient addition rate, system monitoring parameters, residence time requirements, and a theoretical operating model. This study has provided sufficient data to allow a Phase 2 study to proceed.

1.0 INTRODUCTION

1.1 BPOU Consensus Project Overview

For the past several years the Baldwin Park Operable Unit Steering Committee (BPOUSC), U.S. EPA Region IX (EPA), Three Valleys Municipal Water District (TVMWD), and Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of EPA to remediate various plumes of volatile organic compounds (VOCs) in groundwater in the cities of Azusa and Baldwin Park. These plumes extend from north of Interstate 210 in the city of Azusa southwest to the vicinity of Interstate 10 in the city of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU) and the project the BPOU Consensus Project.

The BPOUSC was in the process of negotiating agreements for the project with the EPA, MWD, and TVMWD when in June 1997, concentrations of perchlorate ion above the State of California Department of Health Services (DHS) provisional action level of 18 micrograms per liter (μg/L) were found in BPOU groundwater. Before the project can move forward, the potential impact that perchlorate has on the overall conceptual project design must be evaluated. Work in three specific areas is underway to assess this potential impact so that the conceptual design of the BPOU Consensus Project can be modified and project implementation can begin.

First, the BPOUSC is in the process of defining the distribution of perchlorate in BPOU groundwater through installation of monitoring wells. With the perchlorate plume defined the BPOU Consensus Project extraction plan will be modified to address both VOCs and perchlorate.

Second, the DHS has published a provisional action level for perchlorate in drinking water of 18 μg/L. This concentration is not an enforceable standard but an "advisory" level at which water utilities must notify their customers that perchlorate is present in their water supply. The U.S. Air Force with EPA review is presently performing toxicity studies that will be the basis for a revised Reference Dose (RfD), which will in turn lead to an enforceable water quality standard. Once this numerical value is established, a determination regarding whether BPOU groundwater must be treated for perchlorate can be made.

Third, at the time perchlorate was discovered in BPOU groundwater, no proven treatment technology existed that could reduce low levels of perchlorate in water to a concentration below the DHS provisional action level. The purpose of this Phase 1 Treatability Study and the future Phase 2 Treatability Study is to develop a biological treatment technology that can become part of the BPOU Consensus Project should treatment for perchlorate be needed.

1.2 Biological Reduction of Perchlorate

At the time low concentrations of perchlorate were found in BPOU groundwater, considerable work regarding perchlorate treatment had already been conducted by Aerojet-General Corporation (Aerojet) in Rancho Cordova, California. This work consisted of technology screening, bench-scale and pilot-scale studies of several technologies, and design of a full-scale (4,000 gallon per minute [gpm]) system. The bench- and pilot-scale treatability testing of a biological reduction technology successfully reduced perchlorate concentrations from approximately 8,000 μg/L to less than the 400 μg/L laboratory reporting limit.

The technology can be described as a biological reduction process using a fixed-film bioreactor. A fixed-film of biomass is attached to granular activated carbon operated as a fluidized bed (GAC/FB). Groundwater, amended with an organic substrate (e.g., ethanol) and nutrients (nitrogen and phosphorus) is introduced into the influent stream. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously destroying the perchlorate, reducing it to chloride and oxygen. The bench- and pilot-scale testing demonstrated that the technology was effective in treating perchlorate in groundwater. Design of the full-scale system is complete and construction underway.

There are, however, several important differences between the objectives of the previous pilot-scale work and current objectives for the BPOU Consensus Project. First, the flow rate was 0.1 percent of that needed in the San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in the San Gabriel Basin. Third, the pilot system was not designed to achieve nor did it achieve effluent perchlorate concentrations less than the 18 μg/L provisional action level. Finally, the previous testing was not designed to deliver potable water.

To address these issues, further pilot-scale treatability testing was necessary. The pilot-scale testing was planned in two phases. In this first phase, the objective was to assess if the biological reduction technology could achieve the target effluent goal with influent concentrations similar to that found in BPOU groundwater. A work plan outlining the Phase 1 Treatability Study was prepared, and a copy is included as Appendix A. The work plan was then implemented using a pilot-scale unit operated at the Aerojet facility in Rancho Cordova, California. Deviations from the original work plan are detailed in Appendix B. The results of the Phase 1 Treatability Study are provided in this report.

In the second phase, scientific and engineering data needed to design and construct a full-scale treatment system will be collected. This testing will be performed at a site in the BPOU. A work plan outlining the scope of the Phase 2 Treatability Study is being submitted concurrently with this document.

1.3 Analytical Detection Limits for Perchlorate and Nitrate

The current perchlorate reporting limit is 4 μg/L. This is achievable using a method developed by the DHS. To date, this method has not been peer reviewed. Since perchlorate is not a regulated substance, DHS does not issue laboratory certification for method analysis. However, DHS will issue informal approval to perform perchlorate analysis once a laboratory meets DHS requirements.

The lowest obtainable reporting limit for nitrate analyses is 0.1 milligram per liter (mg/L) (as nitrogen). Nitrate analytical results are reported "as nitrogen." In the text, however, the term "nitrates" will be used to describe the nitrate-nitrogen results. Ammonia results are also reported as ammonia-nitrogen in the analytical laboratory reports.

For the purposes of this report, complete or 100 percent destruction is defined as occurring when the influent concentration of the compound (i.e., perchlorate, nitrate) has been reduced in the effluent to a concentration that is not detectable. Therefore, if an influent perchlorate concentration of 50 μg/L is reduced to nondetect (<4 μg/L) in the effluent, the destruction is considered to be 100 percent.

2.0 TREATABILITY STUDY OBJECTIVES

The objectives of this Phase 1 Treatability Study were to evaluate the performance of the biological reduction treatment technology previously tested at Aerojet's Sacramento facility with modifications described in the following sections. During the course of treatability testing, issues or questions not directly related to attainment of these objectives arose. These issues were addressed to the extent possible. These issues and related results are discussed in Section 5.0.

2.1 Evaluate Lower Perchlorate Influent Concentration

Based on the perchlorate distribution, extraction well configuration and flow rate, and extraction plan modifications for the BPOU Consensus Project, it was estimated that the BPOU extraction system would produce groundwater containing concentrations of perchlorate between 50 and 100 μg/L. The previous pilot-scale testing used groundwater with influent perchlorate concentrations ranging from 7,000 to 8,000 mg/L. One objective of this treatability study was to treat water containing a perchlorate concentration representative of that anticipated in the San Gabriel Basin and determine to what degree the perchlorate could be destroyed.

2.2 Evaluate Higher Nitrate Influent Concentration

Previous pilot-scale testing conducted at Aerojet treated groundwater characterized by low (1.5 mg/L) nitrate concentrations. For the BPOU Consensus Project, influent nitrate concentrations have been estimated between 5 and 6 mg/L (as nitrogen). A second objective of this treatability study was to treat water containing a nitrate concentration representative of that anticipated in the San Gabriel Basin and determine to what degree the nitrate could be destroyed.

2.3 Demonstrate Technology Can Achieve 18 μg/L Perchlorate Limit or Lower

At the time the previous pilot-scale study was performed at Aerojet's Sacramento facility, the goal was to produce effluent that contained perchlorate at a concentration lower than the 400 μg/L laboratory reporting limit current at that time. With a new perchlorate reporting limit of 4 μg/L, the third objective of this treatability study was to evaluate whether the technology could achieve an effluent perchlorate concentration at or below than the DHS provisional action level of 18 μg/L.

2.4 Evaluate Different Source of Microorganisms

The source of microorganisms in the previous pilot-scale study was municipal wastewater treatment plant sludge. This source of microorganisms presents a concern to DHS and water purveyors because the effluent is to be part of a public water supply. Pilot-scale work performed at Aerojet's Sacramento facility demonstrated that pathogens are not present in the pilot plant effluent; however, the potential presence of these pathogens is the primary concern. The fourth objective of this treatability study was to test the effectiveness of waste sludge from the food processing industry, which will likely lack the pathogens that may be of concern.

2.5 Evaluate Potability of Treated Water

For the BPOU Consensus Project to be viable it must deliver potable water to water purveyors. Therefore, the selected treatment train must produce water that meets all federal and state requirements for a potable water supply. Embodied in the objectives described above is the need to produce water that contains acceptable concentrations of perchlorate and nitrate and lacks pathogens. In addition, this pilot-scale testing was to evaluate all other applicable water quality parameters to ensure treatment plant effluent can achieve other potable water quality goals.

3.0 TREATMENT SYSTEM EQUIPMENT DESCRIPTION

During the Phase 1 Treatability Study testing, two equipment configurations were used. The only difference between the two configurations was whether or not the air stripper was operational. These two variations were tested to determine whether, for the BPOU Consensus Project, the bioreactor would function most effectively with the air stripper placed before or after the bioreactor.

During the first portion of the study, the air stripper was operated on the influent side of the bioreactor. Later in the study, the air stripper was removed from the process train. The configuration as used during the initial portion of the study is described below; for the second portion the description remains the same except that the air stripper was shut down and bypassed. A system general arrangement drawing is attached as Plate 1.

First, extracted groundwater was pumped directly to an air stripper for removal of VOCs. Air stripper effluent was then pumped to a point where alcohol addition occurred. After alcohol addition, the groundwater influent water was mixed with recirculation water from the bioreactor (if any). The pilot plant is designed to constantly run at a flow rate of 30 gpm through the bioreactor. System design allows the operators to vary the proportion of groundwater influent and recirculated water. With no input from the well, the system runs with 100 percent recirculated water. Groundwater flow can be increased on a continuum until the pilot plant is running no recirculated water. A table of explaining this breakdown in flow as well as system retention time is attached as Table 1.

The stream of mixed groundwater influent and recirculation water was then pumped to the bioreactor with nutrient feed addition occurring just before the bioreactor inlet. The granular carbon used in the bioreactor was virgin, coal-based carbon in a 10 x 30 mesh. A biological growth control system installed at the top of the reactor removed biomass from the carbon and controlled carbon bed height. The effluent then exited the bioreactor and flowed through a carbon separator system which captured and returned any carbon that flowed out of the bioreactor. Once through the separator, the effluent flowed to a 500-gallon polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent was discharged directly to an Aerojet groundwater extraction and treatment (GET-B) system.

Eight sample ports at key locations throughout the treatment system provided for the collection of water quality samples and measurement of field parameters. These eight sample ports were located as follows:

1. Air stripper inlet line (Port A)

2. Air stripper effluent line (Port B)

3. Air stripper effluent line, post-ethanol injection, pre-dilution (Port BS-C)

4. GAC/FB diluted bioreactor inlet influent line (Port C)

5. 25 percent of bioreactor height (Port D)

6. 50 percent of bioreactor height (Port E)

7. 75 percent of bioreactor height (Port F)

8. Effluent line from the bioreactor (Port G)

The bioreactor unit contained inline reactor influent and effluent dissolved oxygen (DO) sensors, flowmeters, and effluent temperature and pH probes. All other parameters evaluated during the study were measured using hand-held instruments.

4.0 TREATMENT SYSTEM OPERATIONS AND SAMPLING

Pilot plant operations can be divided into two distinct timeframes corresponding to the two different equipment configurations described above. The first equipment configuration introduced a high concentration of DO into the bioreactor. In this equipment configuration the air stripper raised the natural DO concentration in the groundwater from 1 to 2 mg/L to 6 to 8 mg/L as a result of aeration. The second equipment configuration introduced groundwater with lower DO, representative of untreated groundwater, directly into the bioreactor.

A description of the overall operational plan is provided in the original work plan, which is attached as Appendix A. Because of unforeseen conditions and as a result of interpretation of treatability study data, certain deviations from procedures described in the work plan were made. These deviations or modifications to operational procedures as described in the work plan are discussed in Appendix B.

The first portion of pilot plant operations occurred from November 7, 1997, through January 23, 1998. The air stripper provided influent water with high DO concentrations to the bioreactor. Test runs were conducted at recirculated water percentages of 100, 83, 67, 50, 33, 17, and 0 percent (5 gpm increments). Water quality samples were collected and analyzed using EPA-approved methods for VOCs, ammonia (as nitrogen), alkalinity, chloride, phosphorus, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids, total dissolved solids, turbidity, perchlorate, chlorate, chlorite, chloride, nitrate (as nitrogen), nitrite (as nitrogen), sulfate, sulfide, alcohols, metals, and bacteriology. Field parameters, water and ethanol flow rates, pH, temperature, oxidation-reduction potential (ORP), DO, and ethanol flow rates were also collected. A detailed chronology of operations is included as Appendix C. Tables containing analytical laboratory results and results of the measurement of field parameters are included in Appendices D and E, respectively. A table combining representative laboratory analytical and field parameter data collected during both operational timeframes is attached as Table 2.

With high influent DO, complete destruction of perchlorate and nitrate was achieved but could not be routinely maintained, particularly when lower proportions of bioreactor effluent were recirculated. Complete destruction of perchlorate and nitrate was observed at recirculated water percentages of 83, 67, 50, and 33 percent. As operating conditions were changed, intermittent destruction of perchlorate and nitrate was observed. Initial conclusions were that the DO loading was too high for the biomass to be able to consume more of the DO (establishing conditions conducive to perchlorate destruction) and still have adequate residence time in the bioreactor to destroy all of the perchlorate and nitrate. To test this hypothesis and gather performance data for an equipment configuration where air stripping would occur following biological treatment, the air stripper was removed from the treatment system.

The second portion of operations took place from January 24 through March 13, 1998, after the air stripper was removed. Test runs were conducted at recirculated water percentages of 33 and 17 percent. Samples and field parameters as described above and contained in Appendix C were collected. As above, sample analytical and field parameters results are summarized in Appendices D and E. With the influent DO concentration representative of that found in groundwater, complete destruction of perchlorate and nitrate was consistently achieved.

5.0 TECHNOLOGY PERFORMANCE ANALYSIS

Knowledge of biological reduction kinetics and fluidized-bed design are essential when analyzing the technology performance.

5.1 Perchlorate Reduction Theory

Perchlorate reduction is expected to be similar to nitrate reduction. The energy generating portion of the dinitrification reaction with ethanol as the organic substrate (neglecting cell synthesis) is:

$$2 \cdot C_2H_5OH + 6 \cdot NO_3^- + 12H^+ \rightarrow 4 \cdot CO_2 + 3 \cdot N_2 + 12 \cdot H_2O$$

A similar reaction for perchlorate is:

$$2 \cdot C_2H_5OH + 4 \cdot ClO_4^- + 8 \cdot H^+ \rightarrow 4 \cdot CO_2 + 4 \cdot Cl^- + 10 \cdot H_2O$$

Note that nitrate and perchlorate are completely destroyed, and the carbon substrate (ethanol) is oxidized by bacteria to the mineral end products carbon dioxide, water, chloride, and nitrogen. During energy generation in the cell protons are used, thus pH tends to increase during denitrification. We expect a similar pH increase for perchlorate reduction.

5.2 Fluidized-Bed Behavior

In a fluidized-bed reactor, flocculated organisms are suspended by drag forces exerted by the rising liquid; those that are entrained are captured at the top of the tower by expanding the cross section, thereby reducing liquid drag, and fed back into the tower. Thus, by a careful balance between operating conditions and organism characteristics, the flocs are retained in the reactor while the medium flows through it continuously.

A rudimentary model for such fluidized reactors can be developed by assuming that (1) the biological catalyst particles (microbial flocs or immobilized-enzyme pellets) are uniform in size, (2) the fluid-phase density is a function of substrate concentration, (3) the liquid phase moves upward through the vessel in plug flow, (4) the substrate-utilization rates are first order in biomass concentration but zero order in substrate concentration, (5) the catalyst-particle Reynolds number based on the terminal velocity is small enough to justify Stokes' law, and (6) fluid density changes do not affect liquid flow velocity. Assumptions 4 and 5 are reasonable for many applications, and 1 and 3 may be adequate approximations. Bed behavior is then described as:

$$S_e = S_f - k\rho_o \left[1 - \left(\frac{u}{u_t} \right)^{1/4.65} \right] \frac{L}{u}$$

where:

S_f	=	influent substrate concentration (lbm/ft^3)
S_e	=	effluent substrate concentration (lbm/ft^3)
k	=	reaction rate constant (l/min)
L	=	reactor height (ft)
ρ_o	=	microbial density (lbm/ft^3)
u	=	velocity (ft/min)
u_t	=	terminal velocity (ft/min)

The process was generally operated with a recycle stream. A recycle stream (a nonsterile feed) can be used to increase biomass and product yield per unit reactor volume. Use of a recycle stream also permits processing of more feed material per unit time and reactor volume than in a nonrecycle situation.

5.3 Results

The GAC/FB biochemical reduction system was successful in destroying perchlorate and nitrate in the concentration ranges representative of those found in the BPOU under certain conditions. Complete destruction of perchlorate is achieved when (1) anoxic conditions are achieved in the first part of the reactor, (2) ethanol concentrations exceed a critical minimum threshold, and (3) adequate phosphate is available for use by the microbial population. A summary of performance over various timeframes is included as Table 3.

Specific performance parameters are discussed below.

5.3.1 Perchlorate Reduction

During the timeframe from January 28 through March 1, 1998, average perchlorate reduction was 99.6 percent. During this time, the average reactor influent concentration of perchlorate was 34 μg/L. Complete perchlorate destruction to the detection limit of 4 μg/L was not obtained on only three occasions, when the effluent concentration rose above the detection limit to approximately 5 μg/L. One of these occasions occurred the same day the unit was restarted after being shut down over the previous weekend. The other two occasions appear to have been caused by higher concentrations of the influent perchlorate or higher influent concentrations of phosphate or low influent ethanol or a combination of all three.

From March 2 to 13, 1998, the average perchlorate destruction decreased as the amount of ethanol was decreased as ethanol optimization testing was performed. During this time, the average perchlorate reduction was 84.6 percent. The average reactor influent concentration of perchlorate was 39 μg/L.

Under operating conditions conducive to perchlorate destruction, perchlorate is destroyed within approximately 7.5 feet along the reactor flow path. This observation is depicted on Plate 2, which is a plot of perchlorate reactor profiles taken during the time period from January 29 through February 20, 1998. Perchlorate destruction was complete during this timeframe.

Under operating conditions that are not conducive to perchlorate destruction but result in partial perchlorate destruction, the bioreactor profile looks quite different. Plate 3 shows the bioreactor perchlorate profile for three dates in December 1997. During this period, perchlorate destruction varied from approximately 23 to 45 percent.

Products of perchlorate breakdown, such as chlorate, chlorite, and hypochlorite, were difficult to quantify. Chlorate and chlorite analyses of reactor profile samples were conducted. For chlorate, measurable concentrations were present in most of the undiluted groundwater samples and reactor influent samples. However, by the time the flow had reached 25 percent of the reactor flow path, no measurable chlorate remained. During times of incomplete perchlorate and nitrate performance, measurable concentrations of chlorate remained in the effluent. No EPA method exists for hypochlorite analysis; therefore, no analyses were conducted. No detectable concentrations of chlorite were present in any sample collected.

Subsequent sections of this portion of the report explain the controls that affect bioreactor performance.

5.3.2 Nitrate Reduction

From January 28 through March 1, 1998, the average nitrate destruction was 100 percent. The average reactor influent nitrate concentration was 13 mg/L as nitrogen. During operations, copious amounts of nitrogen bubbles were seen rising to the surface of the reactor. Visual inspection can be coupled with analytical data to determine the amount of bubbling and its relation to the extent of nitrate destruction. During the ethanol reduction testing mentioned above, the average nitrate destruction decreased to 99.7 percent; the average reactor influent nitrate concentration remained at 13 mg/L as nitrogen.

Within the bioreactor, most of the nitrate is 25 percent destroyed within a distance of approximately 4 feet along the reactor flow path. This is demonstrated by a plot of nitrate reactor profiles taken during this time period, which is attached as Plate 4. Plate 5 shows bioreactor profiles for several days when the air stripper was online and the influent contained high DO.

In general, nitrate destruction occurred more completely than and before perchlorate destruction. Although nitrate is present in a concentration approximately 300 times greater than that of perchlorate, initial observations support the conclusion that the microorganisms present in the bioreactor prefer nitrate over perchlorate as an electron acceptor.

Effluent concentrations of the nitrate breakdown product nitrite were not detectable (0.03 mg/L as nitrogen) during this entire time period. Nitrite was monitored during the study and was used as an indicator of the overall "health" of the bed. If detectable concentrations of nitrite were present in the bioreactor effluent, it was a sign that the biomass was not "healthy" since nitrate was not being completely broken down to basic nitrogen and oxygen.

5.3.3 Dissolved Oxygen

DO was a crucial parameter in evaluating reactor performance. It was generally found that at low DO concentrations (0.5 to 1 mg/L), the system operated in a stable manner and achieved removal of nitrate and perchlorate to their relative detection limits. At higher DO concentrations (4 to 8 mg/L), complete reduction of perchlorate and nitrate was not achievable at regularly or at low recycle rates (higher DO concentrations result from use of the air stripper).

This phenomenon is best understood in the context of competing reactions. The microorganisms that were introduced to the bioreactor were aerobic; oxygen is their preferred electron acceptor. With excess oxygen available, these microorganisms effect only partial destruction of nitrate and perchlorate. These are the following competing electron acceptor reactions (neglecting cell synthesis and electron balances):

$$1 \cdot C_2H_5OH + 4 \cdot O_2 + 4 \cdot H^+ \xrightarrow{k_1} 2 \cdot CO_2 + 5 \cdot H_2O \qquad [Oxygen]$$

$$2 \cdot C_2H_5OH + 6 \cdot NO_3^- + 12 \cdot H^+ \xrightarrow{k_2} 4 \cdot CO_2 + 12 \cdot H_2O + 3 \cdot N_2 \qquad [Nitrate]$$

$$2 \cdot C_2H_5OH + 4 \cdot ClO_4^- + 8 \cdot H^+ \xrightarrow{k_3} 4 \cdot CO_2 + 10 \cdot H_2O + 4 \cdot Cl^- \qquad [Perchlorate]$$

The field data suggest that the reaction rate for oxygen consumption is much faster than for perchlorate or nitrate. Plates 6 and 7 show DO versus perchlorate and nitrate destruction. These figures demonstrate excellent correlation between influent DO and perchlorate/nitrate removal efficiency. In general, once influent DO drops from a range of 6 to 10 mg/L to less than 2 mg/L, perchlorate destruction becomes complete. (Note: deterioration in perchlorate destruction efficiency in March 1998 is due to the ethanol optimization study.)

A more detailed examination of the profile of DO across the bioreactor confirms the above conclusion. Plate 8 presents the DO profile across the bioreactor on 2 days: one representative of conditions with high influent DO, which resulted in partial perchlorate destruction, and one with low influent DO, which resulted in complete perchlorate destruction. This figure plots reactor bioreactor height on the x-axis. The reactor is 15 feet tall and maintains an average water level at 14 feet. The fluidized bed (carbon) varies in height depending on the health of the biomass. This fluidized bed height varied from 9 to 11 feet with an average bed height of 10 feet.

On January 22, 1998, influent DO was over 5 mg/L with the air stripper online. At 3 feet, or one-third, along the reactor flow path, DO was still between 1 and 2 mg/L. The DO concentration was not reduced to a level of 0.1 mg/L until 6 feet, or 60 percent, along the reactor flow path. This results in less than 4 minutes in the bioreactor under conditions needed for perchlorate destruction. Perchlorate destruction in this timeframe varies from 15 to 25 percent.

On January 23, 1998, the air striper was taken offline. By January 25, 1998, influent DO was approximately 0.5 mg/L. Before flow was less than 1 foot (10 percent) along the reactor flow path, DO was reduced to 0.1 mg/L. This low DO was maintained across the remainder of the bioreactor flow path, which is equivalent to a hydraulic retention time of 5.4 minutes. Perchlorate destruction on this day was complete and remained so for weeks.

With sufficient reactor residence time and high DO, DO is depleted and perchlorate and nitrate destruction proceeds. This residence time is controlled by varying the rate of recycled water. With the air stripper online and complete perchlorate destruction, a maximum well water flow rate of 15 gpm was possible. Although this is only 50 percent of the reactor capacity, this proportion of recycled water increases the effective hydraulic retention time available. With the air stripper offline and complete perchlorate destruction, a maximum well water flow rate of 25 gpm was possible.

Based on the reaction rate kinetics, placing the air stripper after the bioreactor in the final design may result in the lowest total project cost; however, placement of the air stripper will ultimately depend on a variety of factors.

5.3.4 Oxidation-Reduction Potential

Biological reduction of perchlorate and nitrate occurs in an anoxic environment with a reducing ORP. Plate 9 is a plot of effluent ORP versus time from December 9, 1997, to March 13, 1998. Although ORP was measured for bioreactor influent and effluent from system startup in early November 1997, the ORP electrodes were determined to be faulty and were replaced in December.

Plate 10 shows effluent ORP as it related to percent reduction of perchlorate and nitrate during the period from January 25 to March 13, 1998. The ORP for the bioreactor effluent during the period from January 25 to approximately February 27, 1998, ranged from -214 to -328 millivolts (mV). As a result of the performance of ethanol optimization testing, described elsewhere in this section, the average effluent ORP value increased to -185 mV. This increase was due to the absence of sufficient ethanol to sustain the biomass. As a result, the ORP increased and perchlorate reduction deteriorated.

Comparison of ORP data for other periods where the bioreactor was producing perchlorate-free water and periods where only partial destruction of perchlorate was occurring suggests that the optimal operating range for ORP in bioreactor effluent is -250 to -350 mV. Although monitoring of ORP at various positions along the bioreactor flow path was not performed during the Phase 1 Treatability Study, such monitoring during the Phase 2 Treatability Study will likely prove to be as valuable or more valuable than monitoring for DO.

5.3.5 Phosphorus Requirements and Consumption

Results from a wide variety of biological treatability studies, including those using both suspended-growth and fixed-film technologies, confirm phosphorus is a nutrient required for biomass growth and stability. Phosphorus must be present at a minimum concentration regardless of whether it is fully consumed or not.

Phosphorus consumption varied widely over the study as is shown on Plate 11. Overall consumption varied from none to 0.5 mg/L. In general, as shown by the graph, more phosphorus was consumed when perchlorate and nitrate destruction was most successful, as would be expected.

Over the period from January 28 to March 1, 1998, when complete destruction of nitrate and perchlorate was realized, residual effluent phosphorus concentrations ranged from 0.2 to 1.1 mg/L. Prior to that period, when perchlorate and nitrate reduction was not as successful, effluent phosphorus concentrations were often lower than 0.2 mg/L. Observations from the Phase 1 Treatability Study suggest the residual phosphorus concentration in the bioreactor effluent should be greater than 0.2 mg/L to ensure that enough phosphorus exists to support biomass activity. However, no detailed evaluation or optimization of phosphorus loading was performed. Therefore, it may be possible to decrease influent concentrations of phosphorus but still maintain biomass stability. This component of perchlorate and nitrate treatability can be evaluated further during the Phase 2 Treatability Study.

5.3.6 Ethanol Requirements and Consumption

An organic food source (substrate) is required to maintain a healthy biomass. The goal is to provide sufficient influent concentrations such that most of the substrate is consumed in the bioreactor with no excess discharged into the effluent. This study utilized ethanol as a substrate and evaluated optimal ethanol addition rates.

The minimum ethanol concentration required to support the bioreactor biomass was determined to be 50 mg/L. When influent ethanol concentrations drop below this level (50 mg/L), bioreactor performance deteriorates, ethanol consumption drops, and ethanol concentrations in the effluent increase.

The maximum ethanol concentration above which bioreactor performance suffers is 180 mg/L. At ethanol influent concentrations above 180 mg/L, the GAC agglomerated and bed fluidization decreased. This likely decreases the surface area of the fixed film available for reaction and promotes channeling within the GAC. Under these conditions, destruction of perchlorate and nitrate decreased accordingly.

The influent ethanol concentration should fall within a 60 to 140 mg/L working range. Plate 12 is a plot of ethanol in the bioreactor influent versus effluent perchlorate for optimal biological reduction efficiency. This graph demonstrates that the top of the ethanol working range, where complete perchlorate destruction occurs, is approximately 140 mg/L. It also demonstrates that at concentrations above 180 mg/L, perchlorate destruction degrades and is incomplete.

Ethanol consumption under conditions of both low and high influent DO is shown on Plates 13 and 14, respectively. Both figures show that ethanol consumption is occurring across the bioreactor. In fact, most of the ethanol is utilized by the 50 percent point along the reactor flow path in both cases. This consumption is roughly equivalent to a concentration of 70 mg/L. It should be noted that although the bioreactor was consuming ethanol at roughly the same rates in both figures, perchlorate reduction varied due to other conditions (e.g., DO, ORP). Thus, ethanol concentrations need to fall within a range to maintain a healthy biomass and allow for perchlorate and nitrate destruction. Other conditions must also be right for perchlorate destruction.

Optimal reactor performance economics and effluent economics and characteristics occur at the lower end of this working range (Plate 12). A plot of ethanol influent/effluent versus perchlorate effluent data is shown on Plate 15. These data were collected during the ethanol optimization study. During this test period, effluent ethanol concentrations were generally below 20 mg/L. With influent ethanol concentrations of 50 to 75 mg/L, ethanol in the effluent was not detectable (February 25 through March 1, 1998). Furthermore, throughout February and March, concentrations of methanol, an impurity in the denatured ethanol, were not detected at or above the laboratory reporting level of 5 mg/L.

5.3.7 pH As an Indicator of Performance

Biological reduction processes remove acidity (protons), and therefore alkalinity increases. This was confirmed by field observations across the reactor. An increase in pH was expected. A greater reduction "load" results in a greater pH increase across the reactor. The maximum pH increase observed during high DO operations was 0.57 unit. The maximum pH increase during low DO operations was 1.02 units. Thus, pH increase can be used as a general indicator of reactor performance. Air stripping raises pH because carbon dioxide dissolved in groundwater is usually stripped out or removed in the process. When the air stripper was inline, the average influent pH was approximately 8.1 units. With the air stripper removed, the average influent pH decreased to approximately 7.3 units. From January 24 through March 13, 1998, the air stripper was offline.

5.3.8 Reactor Temperature

Little to no sensitivity to temperature was observed during the study. Temperatures ranged from 16 to 19°C. Because of the small concentrations involved and the large specific heat capacity of water, no temperature change was observed across the reactor nor was one expected. We anticipate that extracted groundwater temperatures will be sufficient to support biological growth and that no heating will be required.

5.3.9 Visual Inspection of Biomass/Bioreactor

Visual inspection of the biomass and bioreactor correlated well with bioreactor performance or lack of performance. Therefore, visual observation of the biomass and bioreactor can serve as a valuable indicator and predictor of biomass effectiveness and stability. The biomass displayed four distinct appearances under various conditions. While no laboratory differentiation of these populations was conducted, we suspect that four to five independent species thrived at various times in the reactor. This is consistent with Voltera's competitive exclusion principle: in a closed environment under stable conditions, one species will thrive and all others will become extinct.

- Low Dissolved Oxygen. The biomass was a light translucent tan, formed a spherical configuration around the carbon particles, and was well attached. The biomass/carbon spheres resembled fish eggs with diameters ranging from 2 to 4 millimeters. Diameters appeared to be two to three times the diameter of the carbon particle. Gas bubbles were observed rising to the surface during nitrate reduction; however, it was not possible to correlate the degree of bubbling to nitrate destruction efficiency.

- High Dissolved Oxygen. The biomass varied from a light translucent tan during perchlorate destruction to an opaque white/gray when perchlorate was not being reduced. The biomass was gelatinous, filamentous, and poorly attached to the carbon. Gas bubbles were observed rising to the surface during nitrate reduction; however, it was not possible to correlate the degree of bubbling to nitrate destruction efficiency.

- Excess Ethanol. If ethanol addition was too great, a white mucous substance began to accumulate in the system piping and around the biomass. The high cell mass concentrations caused carbon grains to clump together, slowing bed mixing and fluidization, causing channeling, and resulting in a decreased reactor working volume. This nonuniformity adversely affected perchlorate reduction. In addition, long, filamentous, string-like white/gray biomass was also formed. When the ethanol addition rate was decreased to an appropriate level, these biomass conditions ceased.

5.3.10 Reactor Response and Biomass Stability

When the influent DO levels were low and the biomass healthy, the bioreactor responded relatively quickly to changes in flow rate. Typically within 24 hours after an increase in flow rate or a startup of the system, complete perchlorate and nitrate destruction was established.

Several times over the course of the Phase 1 Treatability Study the bioreactor was completely shut down. In one instance, due to weather, power to the entire section of the Aerojet facility was lost for 4 days. Once power was re-established, the bioreactor returned to completely destroying perchlorate and nitrate within 2 days. In two instances after this power outage the bioreactor was completely shut down in anticipation of a power outage to repair power lines damaged during the previous storm or to perform routine maintenance. In both cases, bioreactor performance was re-established within approximately 24 hours.

When the influent DO levels were high, the bioreactor response varied greatly. With high influent DO, complete destruction of perchlorate and nitrate could be achieved by adjusting the rate or recycled water. If complete destruction of nitrate or perchlorate had been established at one flow rate, it generally took 2 days or longer to re-establish complete destruction at the next higher flow rate. Several times when flow rate was increased, complete perchlorate and nitrate destruction was not achieved. In general at least 5 days was allowed to determine if optimum performance would be achieved. Often by this time, the health of the biomass had significantly deteriorated either due to washout or because the biomass populations substantially decreased. Visual observations confirmed this fact. To re-establish the biomass, the recycle flow rate must be substantially increased and several days' time was required.

5.4 Effluent Characteristics/Water Quality

One of the primary objectives of the Phase 1 Treatability Study was to evaluate whether effluent from the biological reduction process can be delivered as potable water to regional and local water purveyors. This means that effluent water quality must meet all federal and state water quality standards, including those of the California Code of Regulations, Title 22. To accomplish this objective, several discrete activities were performed. The specific activities undertaken during the Phase 1 Treatability Study and planned for the Phase 2 Treatability Study were identified as a result of discussions with DHS, TVMWD, MWD, and local water purveyors.

One concern expressed by DHS regards the characteristics of the source of microorganisms used to inoculate the bioreactor. The microorganisms used in this study were taken from a baby food processing plant and proved to be acceptable for building needed populations of microorganisms. Over the life of the study, 97 percent of the results for analysis of fecal coliform showed no fecal coliform was present. Only two measurable results of 1 Most Probable Number (MPN)/100 mL were obtained. These results are extremely close to the method detection limit of 0 MPN/100 mL. General coliform was present, however, to some degree in nearly every effluent sample. From January 28 to March 1, 1998, coliform was present in the bioreactor effluent 78 percent of the time at an amount greater than 200.5 MPN/100 mL (the upper quantifiable limit of the method). These levels of bacteria are common for surface waters, and conventional disinfection and filtration are expected to bring the water to potable standards.

Since ethanol is added to the bioreactor as an organic substrate to support microorganism growth, the presence of ethanol and its impurities in bioreactor effluent was addressed. The ethanol used in the Phase 1 Treatability Study was denatured and contained low concentrations of methanol. The goal was to ensure that the influent ethanol concentration was sufficiently high to ensure perchlorate and nitrate destruction but also to optimize influent ethanol so that the microorganisms consume all the ethanol by the time water flows from the bioreactor. As discussed above, an ethanol optimization study was performed in late February 1998. Analytical results shown in Appendix D demonstrate that with an influent ethanol concentration of 60 to 70 mg/L, ethanol in bioreactor effluent was less than the 5 mg/L laboratory reporting limit.

When the decision was made to test the performance of the bioreactor without first removing VOCs, a concern arose regarding whether unwanted byproducts such as vinyl chloride would develop. Testing for VOC degradation products showed no detectable concentrations of VOC degradation products commonly associated with anaerobic conditions. A single detection of vinyl chloride was deemed an anomaly. Therefore, it was concluded that the slightly reducing, anoxic conditions present in the bioreactor are not sufficiently reducing to cause VOC degradation.

On several occasions, analysis of bioreactor influent and effluent for the full range of water quality parameters required under Title 22 was performed. Results are reported in Appendix D. These results demonstrate that with disinfection and filtration, the water produced from the intended treatment train will meet potable standards.

6.0 CONCLUSIONS

The conclusions of this Phase 1 Treatability Study with respect to the study objectives are:

- **Evaluate Lower Perchlorate Influent Concentration.** The biological reduction process successfully treated groundwater with perchlorate concentrations representative of that anticipated in the San Gabriel Basin.

- **Evaluate Higher Nitrate Influent Concentration.** The biological reduction process successfully treated groundwater with nitrate concentrations representative of that anticipated in San Gabriel Basin to less than the laboratory detection limit of 0.1 mg/L.

- **Demonstrate Technology Can Achieve 18 μg/L Perchlorate Limit or Lower.** The biological reduction process produced an effluent concentration of less than the laboratory detection limit of 4 μg/L, less than the DHS provisional action level of 18 μg/L.

- **Evaluate Different Source of Microorganisms.** This treatability study demonstrated the effectiveness of a different source of microorganisms. This study utilized waste sludge from the food processing industry. Laboratory analysis indicated a lack of pathogens that may be of concern; however, disinfection of the effluent will be necessary to ensure that potable water quality standards are met. It is likely that a variety of sources of microorganisms contain microbes capable of reducing perchlorate; the key concern will be locating a source that does not contain human pathogens.

- **Potability of Treated Water.** The study demonstrated that with disinfection and filtration, the water produced from the intended treatment train will meet potable standards.

Additional conclusions that can be drawn from the study are:

- The conceptual model agrees well with the actual results. A sound conceptual model assists with interim and full-scale design.

- Reactor retention time can be adjusted to achieve complete perchlorate reduction with varying influent conditions. An increased recycle rate provides a greater average reactor residence time and allow the reduction reaction to proceed to completion.

- ORP and pH subjectively indicate perchlorate reduction. This will minimize laboratory costs in the future and aid in the development of automated controls and safety mechanisms.

- An optimal ethanol addition rate is approximately 60 to 80 mg/L. The optimal ethanol addition rate is when there is sufficient ethanol to sustain biomass that will completely degrade perchlorate but there is little to no ethanol in the effluent.

- A minimum biomass phosphorus requirement is 0.4 to 0.5 mg/L. The phosphorus requirement is the minimum addition of phosphorus that sustains biomass growth. The biomass phosphorus requirement is dependent on influent mineral concentrations and may change in the San Gabriel Basin.

- There was an apparent selectivity for nitrate over perchlorate; however, the concentration ranges of nitrate and perchlorate were vastly different. Therefore, it is not clear whether the selectivity was reaction-rate driven or concentration driven.

- No VOC reduction products were present in the effluent. Some VOC reduction products are more toxic and more difficult to remove than their parent compound. The lack of VOC reduction products allows more flexibility in designing the treatment system.

- The reaction proceeds well at nominal groundwater temperatures. Anticipated temperature fluctuations in San Gabriel Basin groundwater are moderate and should be compensated for through other reactor performance parameters.

7.0 REFERENCES

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TABLES

Table 1. Flowrate vs Percent Flow and Effective Retention Time

Influent Well Water Flowrate (gpm)	Recycle Water Flowrate (gpm)	Percent Influent Well Water	Percent Recirculated Water	Estimated Effective Retention Time (min)
0	30	0%	100%	---
5	25	17%	83%	21.6
10	20	33%	67%	10.8
15	15	50%	50%	7.2
20	10	67%	33%	5.4
25	5	83%	17%	4.3
30	0	100%	0%	3.6

Notes:
To calculate effective retention time several assumptions were made:
1) The time calculated is the retention time that the water is in contact with fluidized carbon.
2) With an average settled carbon bed height it was assumed that the carbon void space was 40%.

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Table 2. Representative Laboratory Analytical/Field Parameter Summary

	DATE SAMPLED / MEASURED	12/11/97	12/12/97	12/13/97	12/14/97	12/15/97	12/16/97	12/17/97	12/18/97	12/19/97	12/20/97	1/29/98	1/30/98	2/1/98	2/2/98	2/3/98	2/4/98	2/6/98
	PERCENT INFLUENT WELL WATER	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	83%	83%	83%	83%	83%	83%	83%
	PERCENT RECIRCULATED WATER	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	17%	17%	17%	17%	17%	17%
	AIR STRIPPER OPERATIONAL?	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
SAMPLING PORT	ANALYTE/PROPERTY																	
Undiluted GW (BS)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	110.0	83.0	-	99.0	120.0	110.0	92.0
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	87	84	48	50	78	82.0	84.0	65.0	<5	110.0	98.0	71.0	100.0	95.0	97.0	76.0	40.0
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	37	50	<10	<10	12	-	7.2	<5	30.0	73.0	53.0	30.0	20.0	18.0	23.0	14.0	<5
Undiluted GW (BS)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	36.0	25.0	-	57.0	35.0	28.0	38.0
Reactor Influent (C)	Perchlorate (ug/l)	41	39	40	40	36	42.0	34.0	35.0	34.0	34.0	<4	18.0	20.0	29.0	35.0	27.0	41.0
Reactor Effluent (G)	Perchlorate (ug/l)	27	34	40	29	24	25.0	26.0	28.0	30.0	30.0	<4	<4	<4	<4	<4	<4	<4
Undiluted GW (BS)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	0.11	0.09	-	0.09	0.10	0.12	0.10
Reactor Influent (C)	Total Phosphorus (mg/l)	<0.05	0.46	0.28	0.27	0.26	0.25	0.25	0.41	0.47	0.43	0.62	0.84	0.75	0.53	0.57	0.79	0.52
Reactor Effluent (G)	Total Phosphorus (mg/l)	<0.05	0.37	0.15	0.17	0.15	0.13	0.15	0.27	0.27	0.31	0.43	0.60	0.53	0.34	0.35	0.55	0.34
Undiluted GW (BS)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	0.16	<0.1
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	0.14	<0.1	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1	0.59	0.78	0.66	0.51	0.59	0.72	0.62
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.82	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.57	0.55	0.54	0.29	0.44	0.73	0.75
Undiluted GW (BS)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	17.00	22.00	-	18.00	17.00	18.00	19.00
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	11	14	0.21	13	13	11.00	10.00	11.00	8.90	10.00	14.00	14.00	16.00	15.00	14.00	13.00	14.00
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	7.9	9.5	2	<0.1	0.64	0.55	<0.1	2.40	<0.1	3.90	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Undiluted GW (BS)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	0.04	<0.03	0.051	<0.03	<0.03	<0.03	0.12	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.53	0.33	1.6	0.034	0.18	0.17	<0.03	0.26	<0.03	0.28	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Undiluted GW (BS)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	270.0	-	-	-	-	160.0	160.0
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	100	120	110	91	100	-	87.0	110.0	<10	200.0	300.0	200.0	240.0	280.0	350.0	130.0	140.0
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	98	98	69	52	52	52.0	56.0	74.0	56.0	120.0	240.0	170.0	190.0	160.0	300.0	230.0	65.0
Reactor Influent (C)	pH	7.96	7.67	7.49	7.60	8.22	7.91	7.75	7.28	7.82	-	7.17	7.13	-	7.35	7.27	7.20	7.08
Reactor Effluent (G)	pH	7.64	7.87	7.56	8.17	8.58	8.36	8.19	7.72	7.99	-	7.76	-	7.87	7.80	7.81	7.70	7.67
Reactor Influent (C)	Temperature °C	18.3	17.5	17.8	18.3	18.5	18.6	18.7	17.2	19.0	17.2	19.2	18.9	-	19.1	19.0	19.0	18.9#
Reactor Effluent (G)	Temperature °C	18.6	16.3	16.7	17.3	18.5	18.7	18.8	17.7	19.1	17.4	18.7	-	17.9	18.0	17.8	19.2#	19#
Reactor Influent (C)	Oxidation-Reduction Potential (mV)	118.5	153.3	228.6	108.6	104.6	90.8	76.0	-	65.5	105.6	-208.8	-202.7	-226.0	-243.8	-253.9	-249.5	-241.0
Reactor Effluent (G)	Oxidation-Reduction Potential (mV)	35.0	180.5	172.7	71.4	96.0	42.5	40.8	-	65.0	37.8	-274.0	-281.0	-304.2	-310.0	-323.0	-318.0	-314.1
Reactor Influent-Inline Meter (C)	Dissolved Oxygen	8.3	8.1	-	8.2	8.4	8.0	8.5	8.3	9.2	9.3	0.8	0.9	1.2	0.7	0.5	0.8	1.0
Reactor Effluent-Inline Meter (G)	Dissolved Oxygen	0.3	2.0	0.5	0.2	0.2	0.2	0.2	0.3	0.3	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.4
Inside Reactor Influent	Dissolved Oxygen	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.50	-	0.35
Inside Reactor Effluent	Dissolved Oxygen	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.08	-	0.11

Notes:
ug/l = microgram per liter, mg/l = milligram per liter
mV = millivolt
GW = groundwater
Dissolved Oxygen measured inside the reactor was measured by lowering DO probe directly inside reactor.
= temperature measured directly inside reactor with DO probe, all other temps measured at sample ports with hand-held meter.
pH and ORP measured at sample ports with hand-held meter.

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Table 3. Performance Summary

Date	Air Stripper Operational?	System Flow Percent Influent Well Water	Percent Recirculated Water	Average Percent Perchlorate Destruction	Average Percent Nitrate Destruction	Average Ethanol Consumption (mg/L)	Average Phosphorus Consumption (mg/L)	Average ORP (mV)	Average DO Influent (mg/L)	Effluent (mg/L)	Average pH Increase Across Bioreactor
11/20/97 - 11/25/97	Yes	33%	67%	90	42	9	0.05	---	0.5	0.1	0.06
11/26/97	Yes	50%	50%	100	100	42	0.12	---	0.4	0.1	0.16
11/28/97 - 12/6/97	Yes	67%	33%	74	56	34	0	---	4.4	1.1	0.04
12/11/97 - 12/22/97	Yes	100%	0%	30	75	44	0.13	+74	8.8	0.5	0.25
12/24/97 - 12/26/97	Yes	83%	17%	32	60	30	0.1	+28	9	0.5	0.11
12/29/97 - 1/23/98	Yes	67%	33%	34	79	21	0.01	-103	5.6	0.3	0.23
1/25/98 - 1/27/98	No	67%	33%	100	100	14	0.1	-228	0.7	0.1	0.56
1/29/98 - 2/7/98	No	83%	17%	100	100	59	0.22	-298	0.45	0.09	0.58
2/10/98 - 3/1/98	No	83%	17%	99	100	75	0.14	-280	0.43	0.14	0.44
3/3/98 - 3/13/98*	No	83%	17%	85	99.7	64	0.17	-185	0.4	0.09	0.86

Notes:
* = Decrease in perchlorate and nitrate destruction is due to ethanol reduction testing taking place over time period.
100% destruction is assumed when influent concentration of perchlorate or nitrate is reduced to below the detection limit (i.e. non-detect) in the system effluent.
ORP = Oxidation Reduction Potential
DO = Dissolved Oxygen

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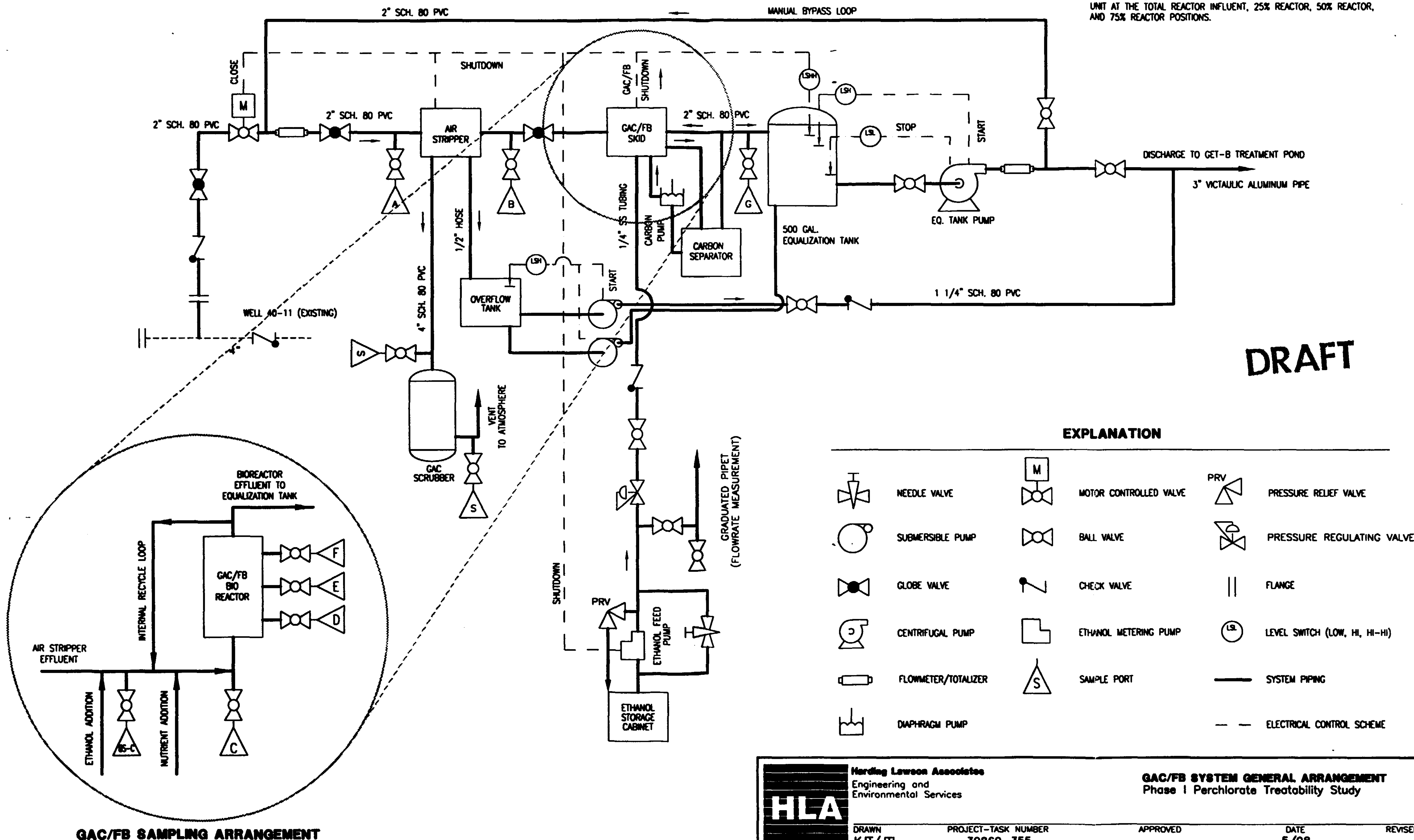
PLATES

CONFIDENTIAL BUSINESS INFORMATION

NOTES:
SAMPLE PORTS C THROUGH F ARE CONTAINED WITHIN THE ENVIREX UNIT AT THE TOTAL REACTOR INFLUENT, 25% REACTOR, 50% REACTOR, AND 75% REACTOR POSITIONS.



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Engineering and Environmental Services

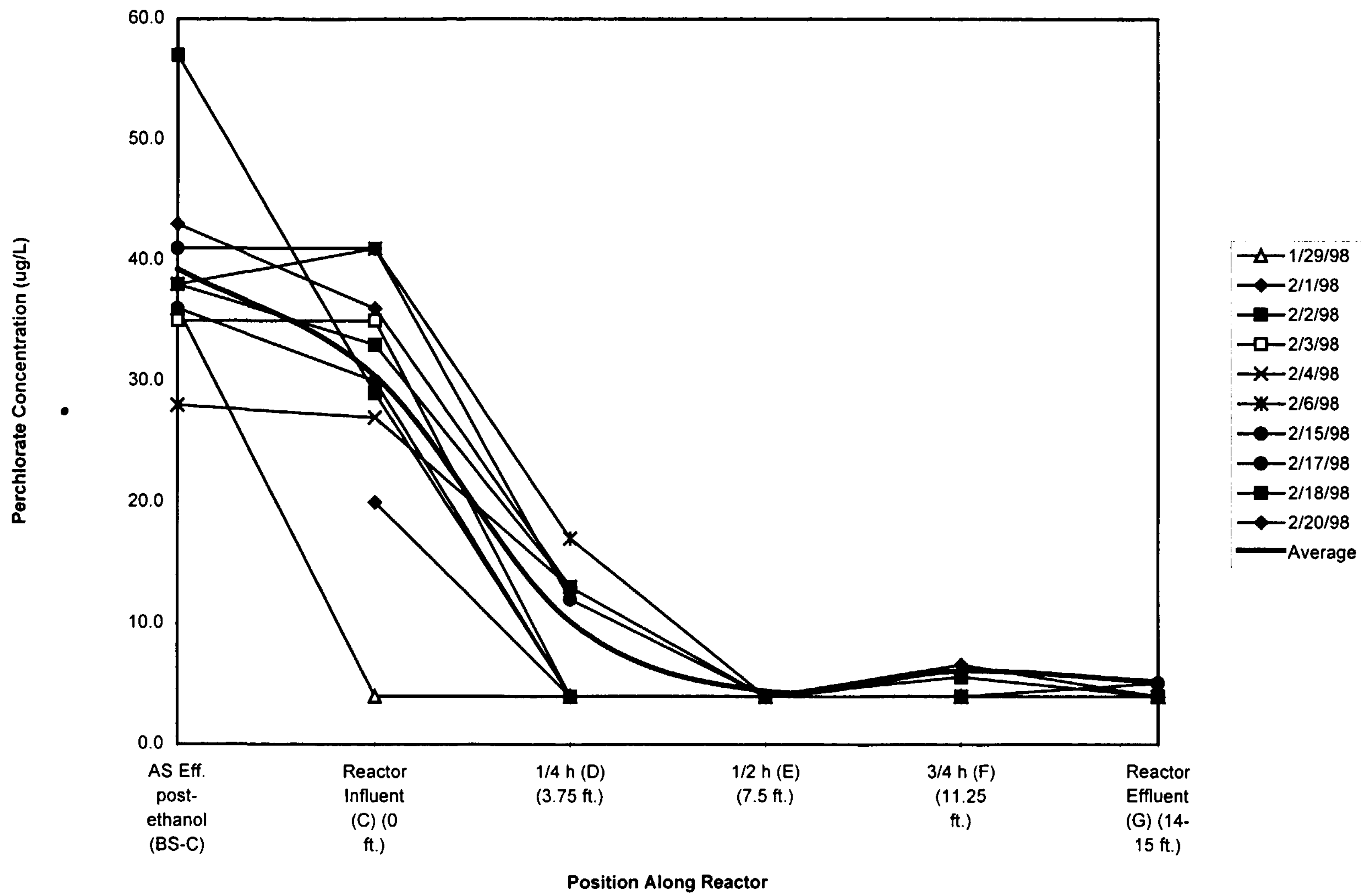
GAC/FB SYSTEM GENERAL ARRANGEMENT
Phase I Perchlorate Treatability Study

PLATE 1

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
KJT/JTL	39860-355		5/98	

R14 PLOT 1 = 1 TO 4MY HOT\39860\355\PHS1PID

R14 PLOT 1 = 1 TO 4MV HDT\39860\355\598T01



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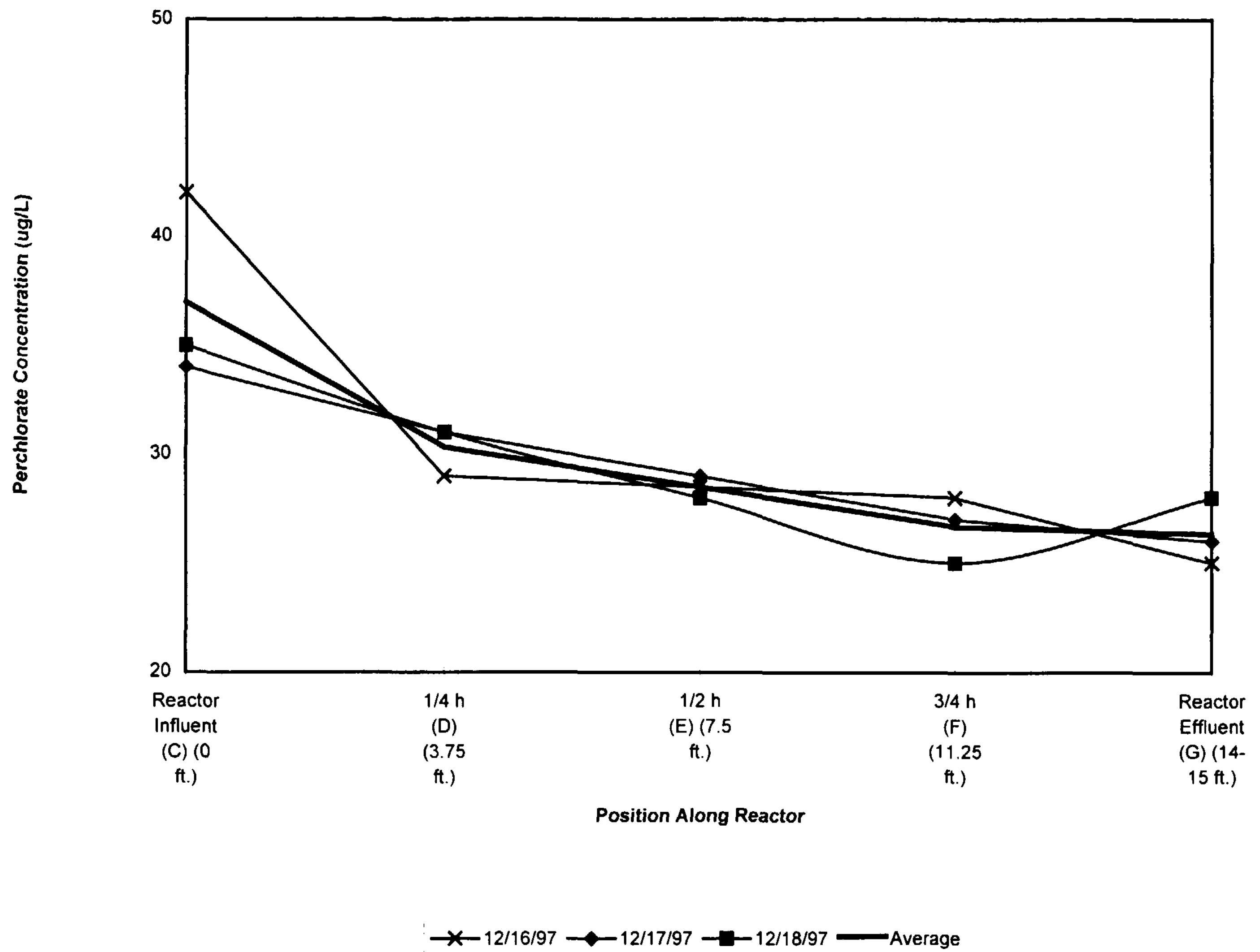
Engineering and Environmental Services

PERCHLORATE REACTOR PROFILES
INFLUENT DO RANGE (0.5 - 1.3 mg/L), 17% RECIRCULATION
COMPLETE/NEAR COMPLETE DESTRUCTION
Phase I Perchlorate Treatability Study

PLATE 2

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	

R14 PLOT 1 = 1 TO 4MV HDT\39860\355\598T02



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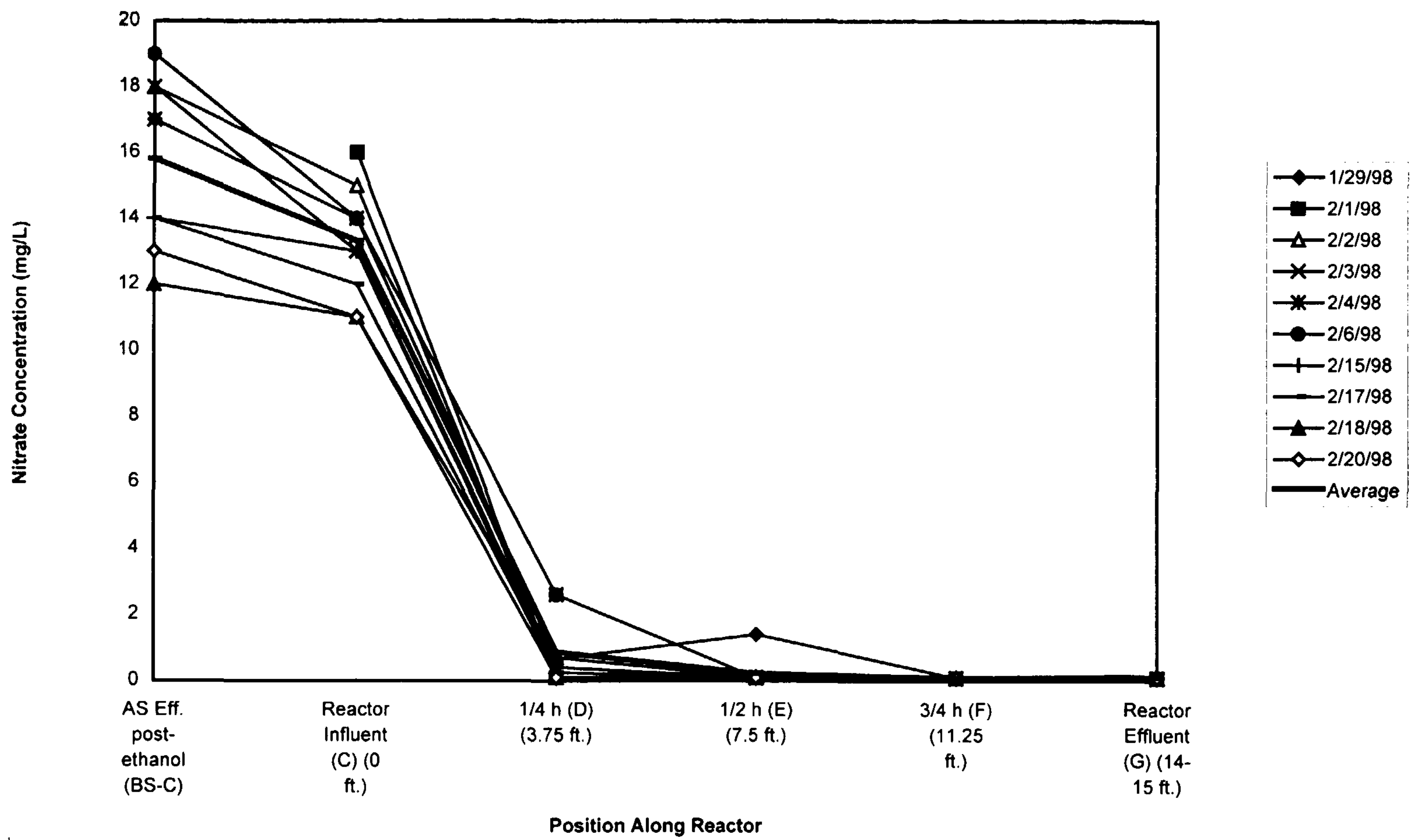
Engineering and
Environmental Services

PERCHLORATE REACTOR PROFILES
INFLUENT DO RANGE (8 - 8.5 mg/L), 0% RECIRCULATION
INCOMPLETE DESTRUCTION
Phase I Perchlorate Treatability Study

PLATE **3**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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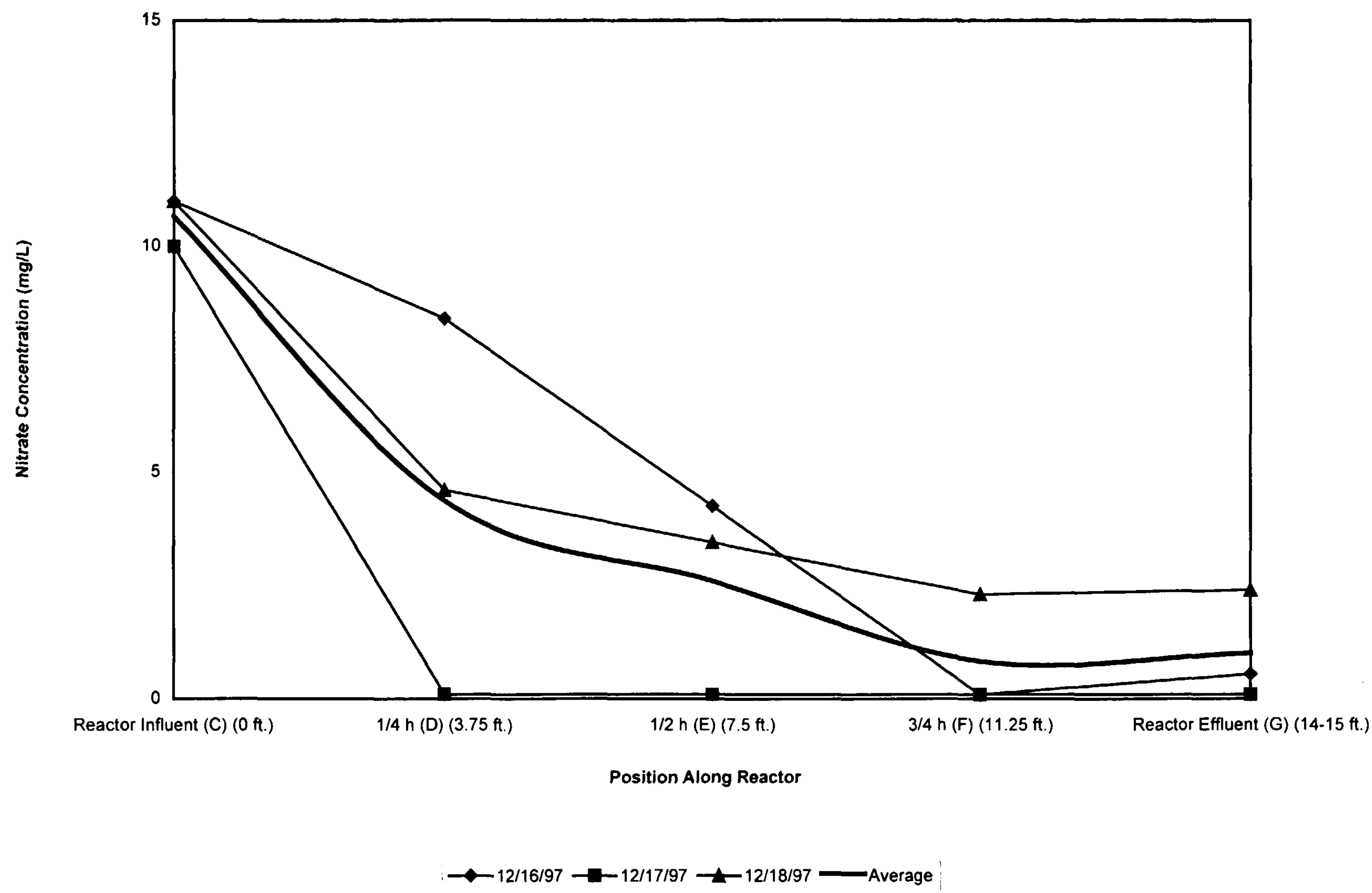
Engineering and Environmental Services

NITRATE REACTOR PROFILES
INFLUENT DO RANGE (0.5 - 1.3 mg/L), 17% RECIRCULATION
COMPLETE DESTRUCTION
Phase I Perchlorate Treatability Study

PLATE 4

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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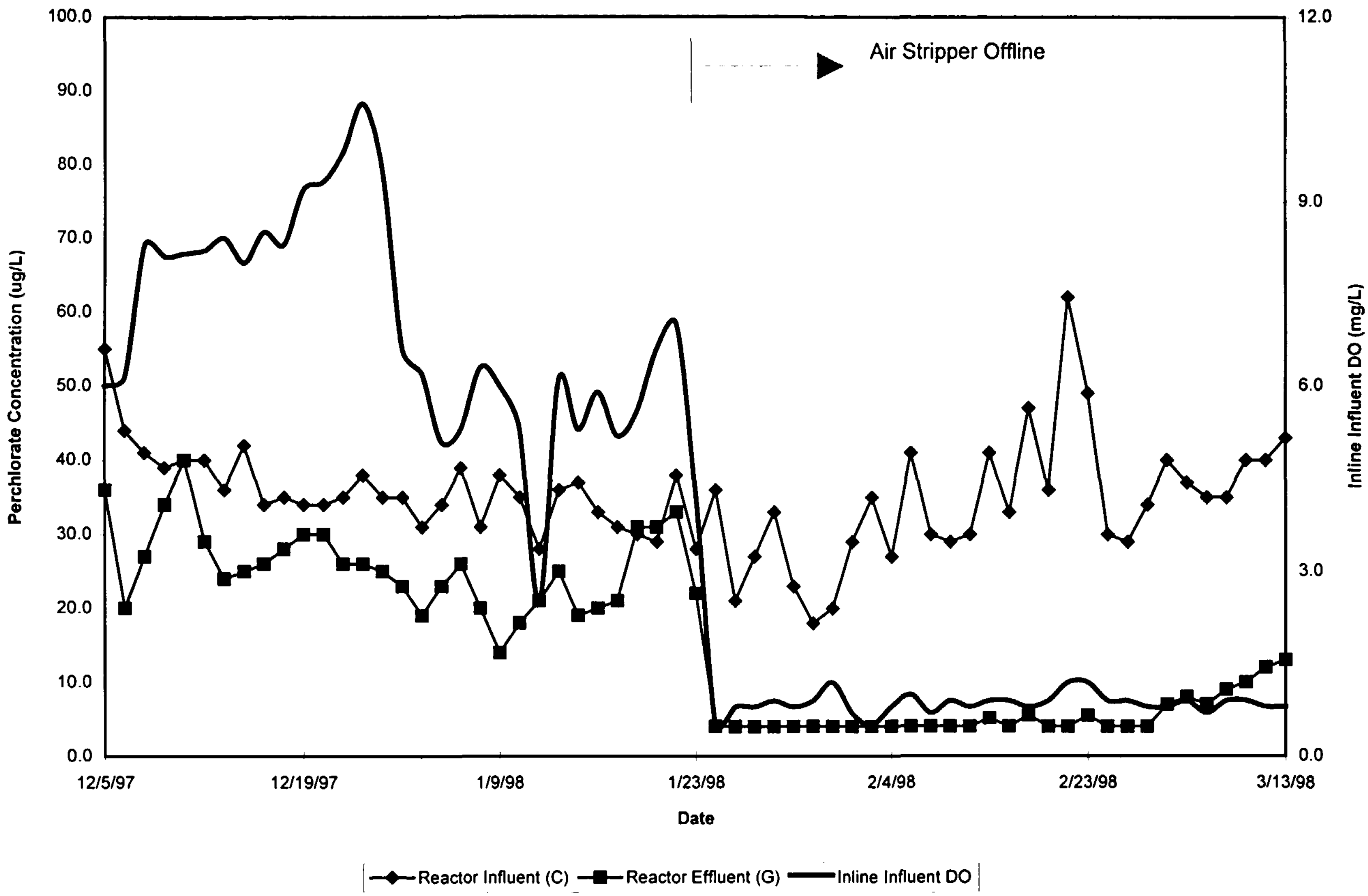
Environmental Services

NITRATE REACTOR PROFILES
INFLUENT DO RANGE (8 - 8.5 mg/L), 0% RECIRCULATION
COMPLETE/INCOMPLETE DESTRUCTION
Phase I Perchlorate Treatability Study

PLATE **5**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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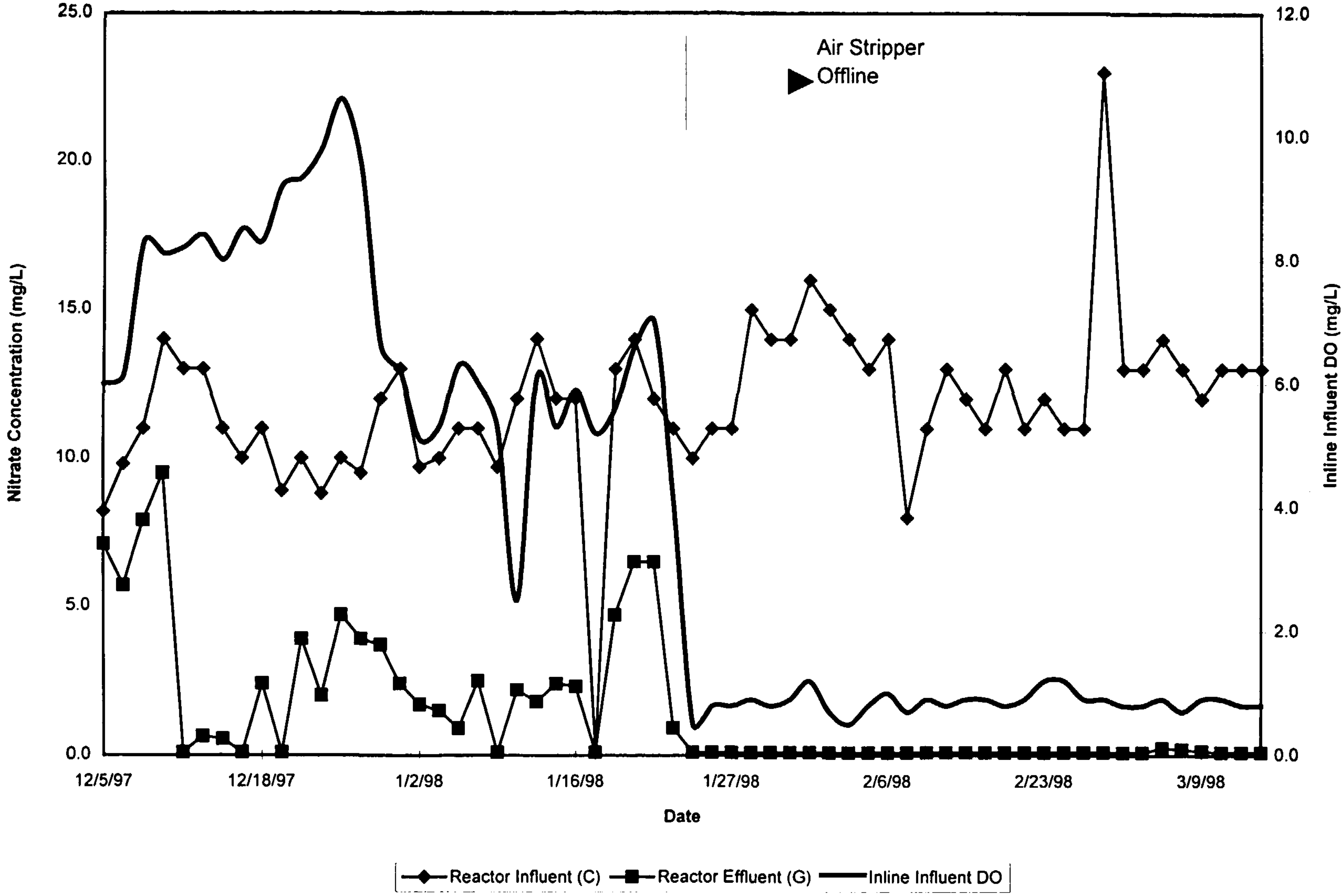
PERCHLORATE DESTRUCTION vs. INFLUENT DO
12/5/97 - 3/13/98
Phase I Perchlorate Treatability Study

PLATE **6**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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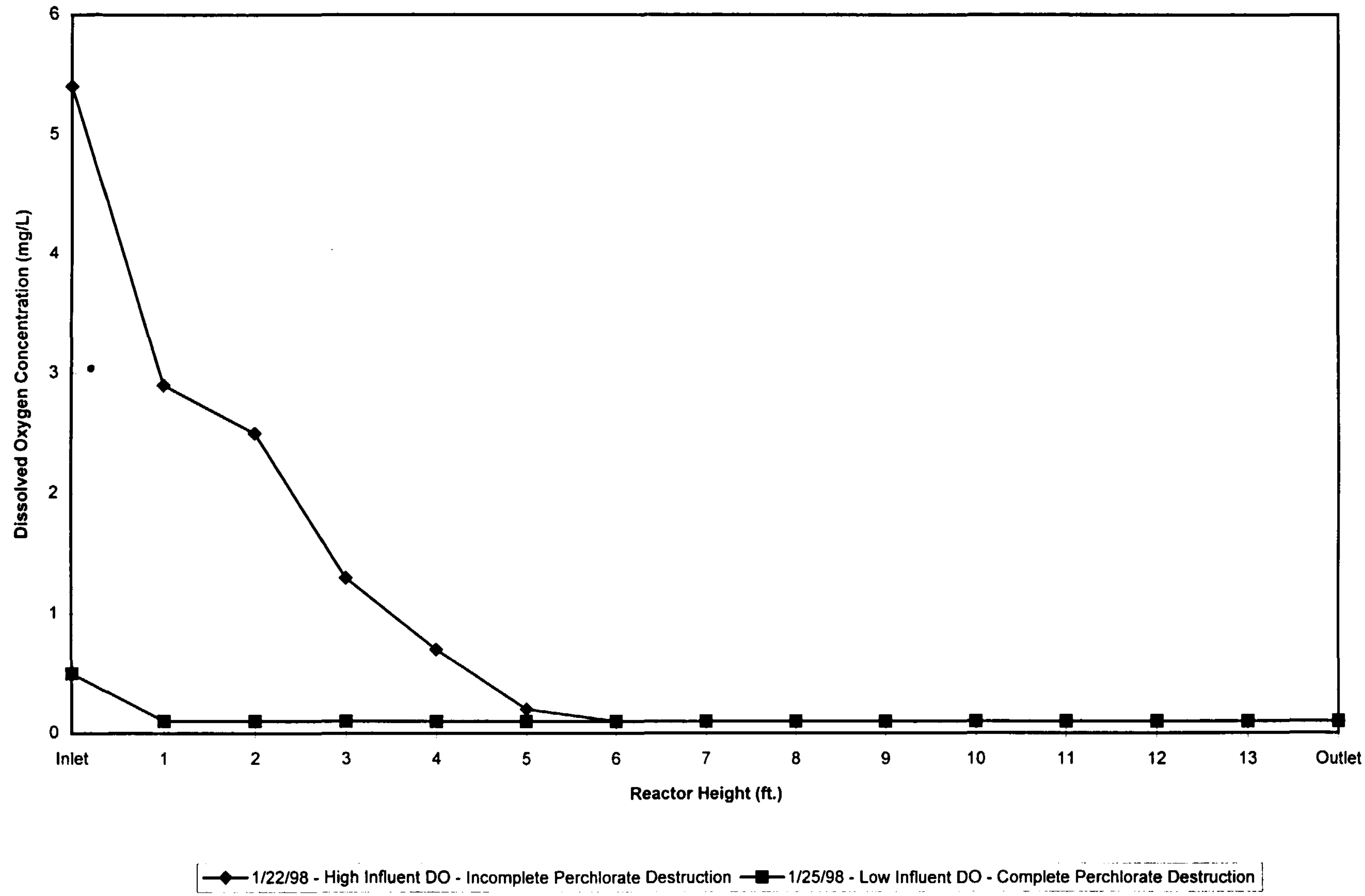
NITRATE DESTRUCTION vs. INFLUENT DO
12/5/97 - 3/13/98
Phase I Perchlorate Treatability Study

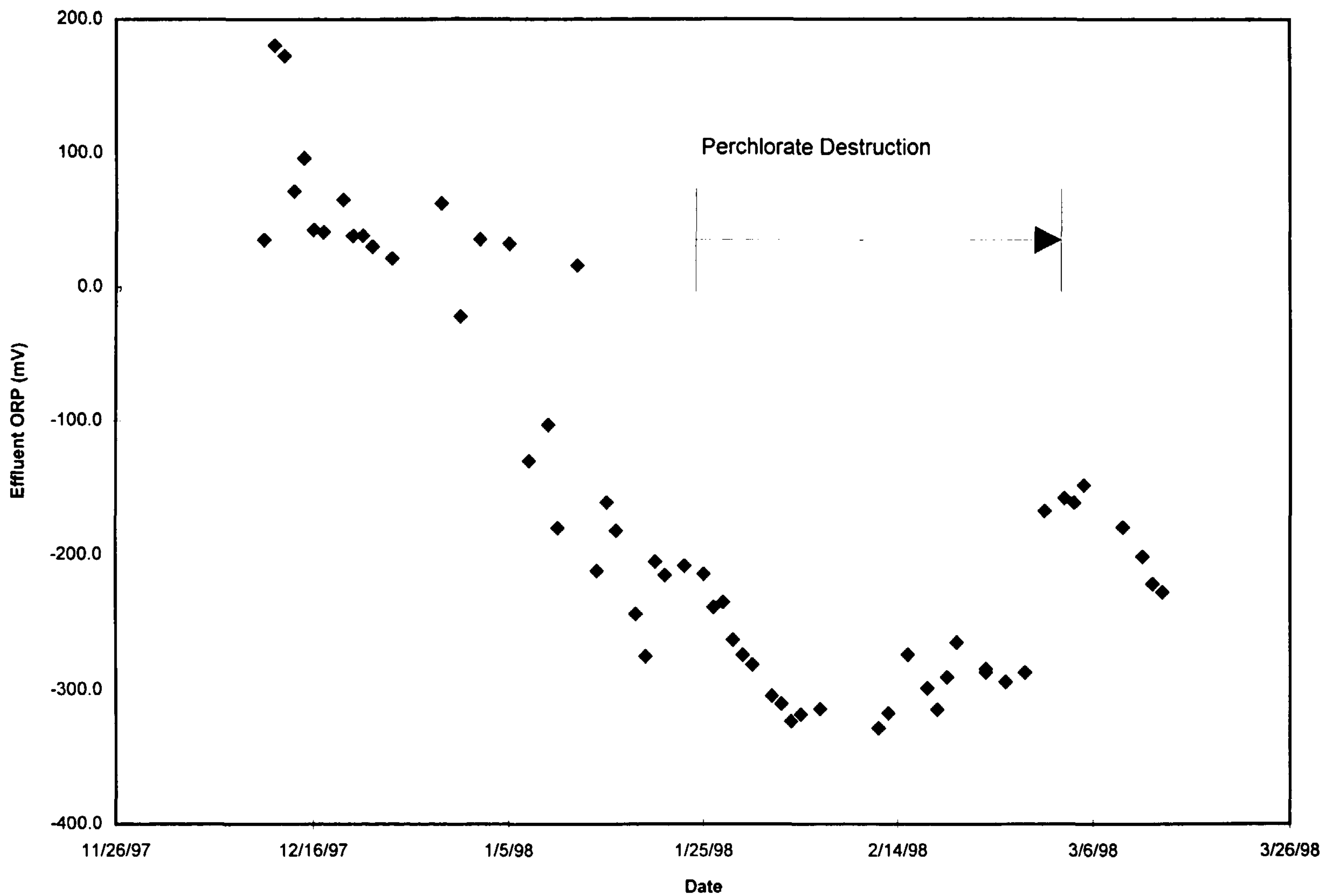
PLATE
7

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



DRAFT

Harding Lawson Associates Engineering and Environmental Services		DISSOLVED OXYGEN PROFILES FOR INCOMPLETE/ COMPLETE PERCHLORATE DESTRUCTION Phase I Perchlorate Treatability Study		PLATE 8
DRAWN JTL	PROJECT-TASK NUMBER 39860-355	APPROVED	DATE 5/98	REVISED DATE



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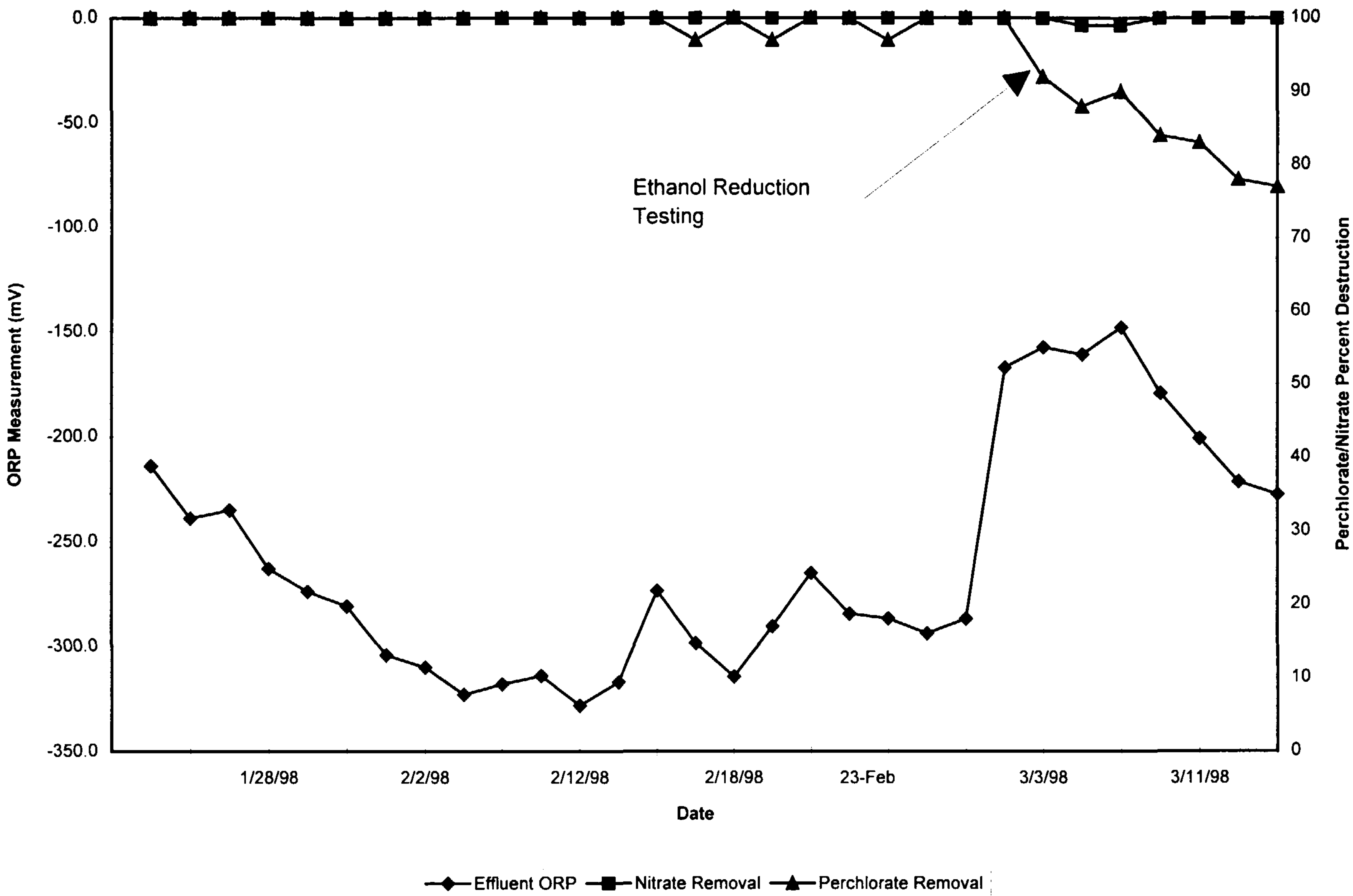
EFFLUENT ORP vs. TIME
Phase I Perchlorate Treatability Study

PLATE
9

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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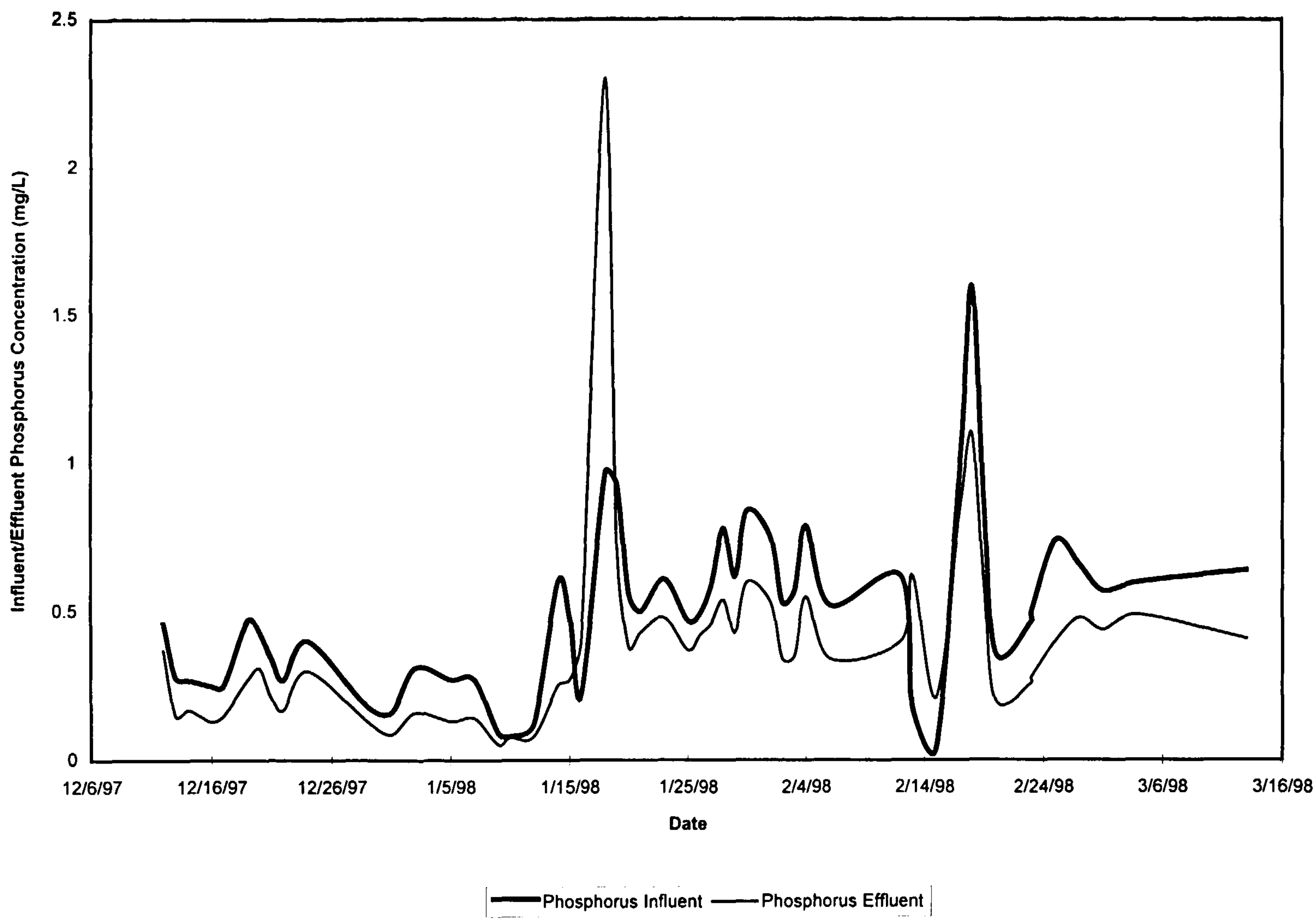
EFFLUENT ORP vs. PERCHLORATE/NITRATE DESTRUCTION
INFLUENT DO RANGE (0.5 - 1.2 mg/L)
Phase I Perchlorate Treatability Study

PLATE **10**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	

R14 PLOT 1 = 1 TO 4MV HDT\39860\355\598T07



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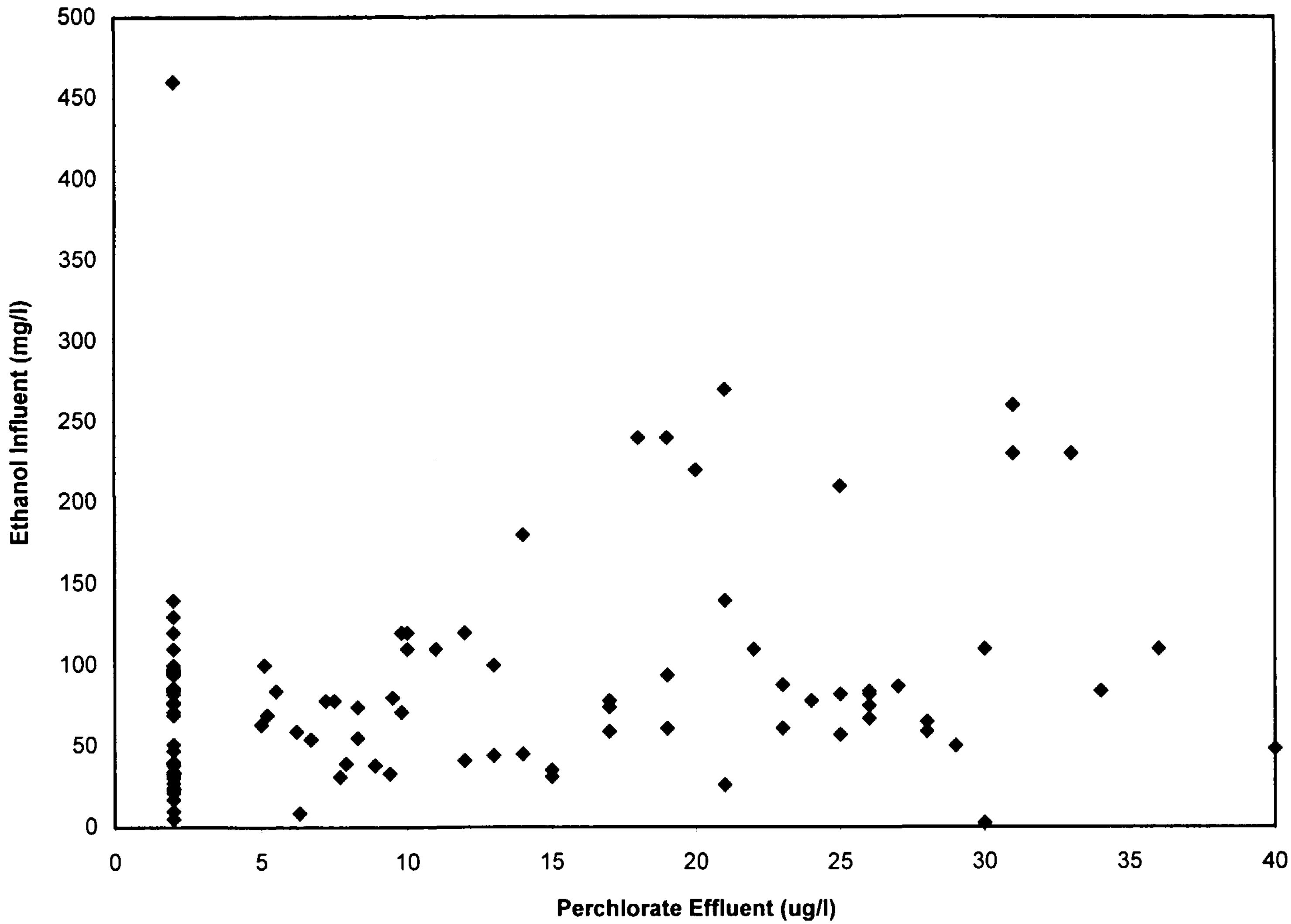
HLA **Harding Lawson Associates** Engineering and Environmental Services		**PHOSPHORUS INFLUENT/EFFLUENT vs. TIME** Phase I Perchlorate Treatability Study		PLATE **11**
DRAWN JTL	PROJECT-TASK NUMBER 39860-355	APPROVED	DATE 5/98	REVISED DATE



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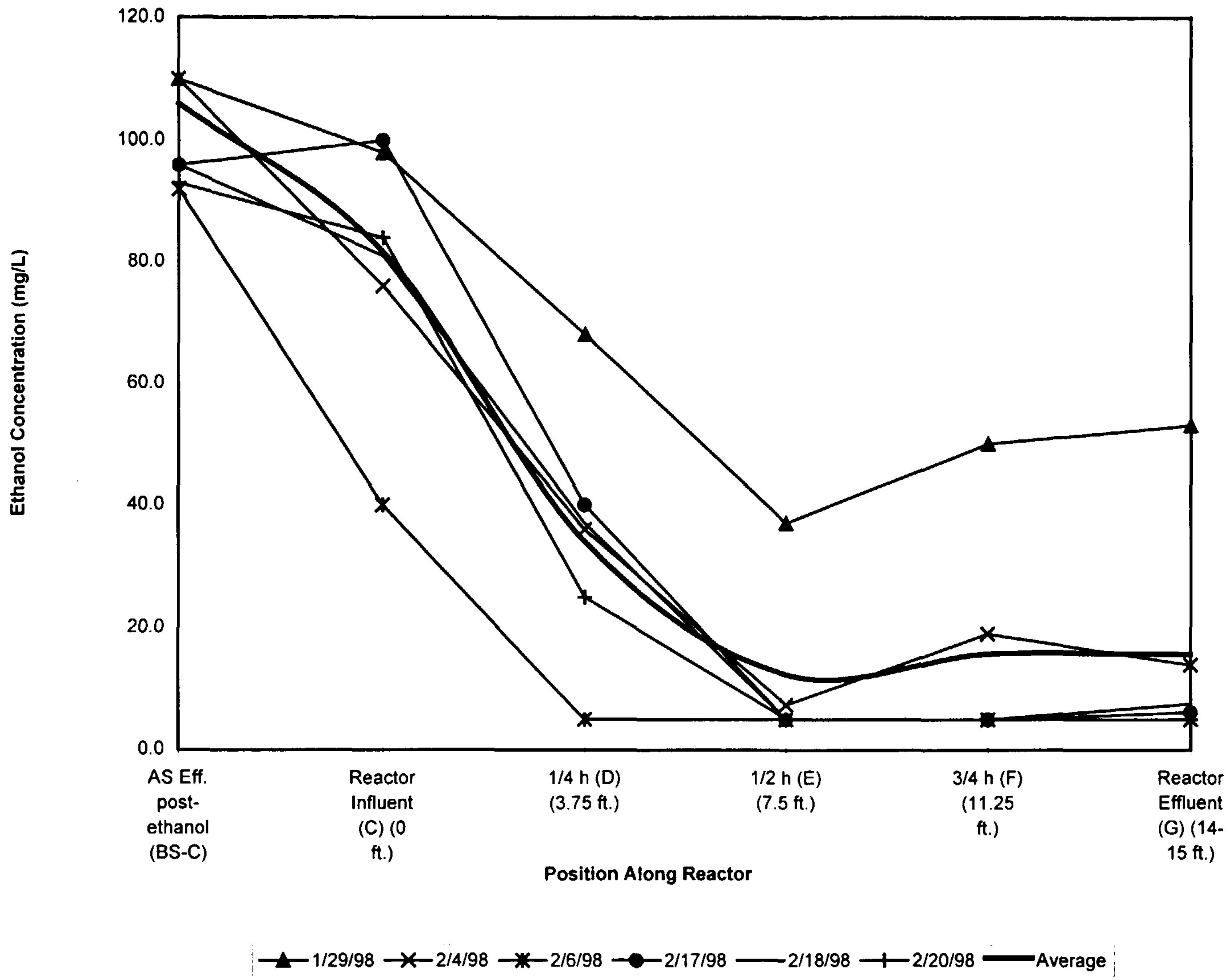
PERCHLORATE EFFLUENT vs. ETHANOL INFLUENT
Phase I Perchlorate Treatability Study

PLATE
12

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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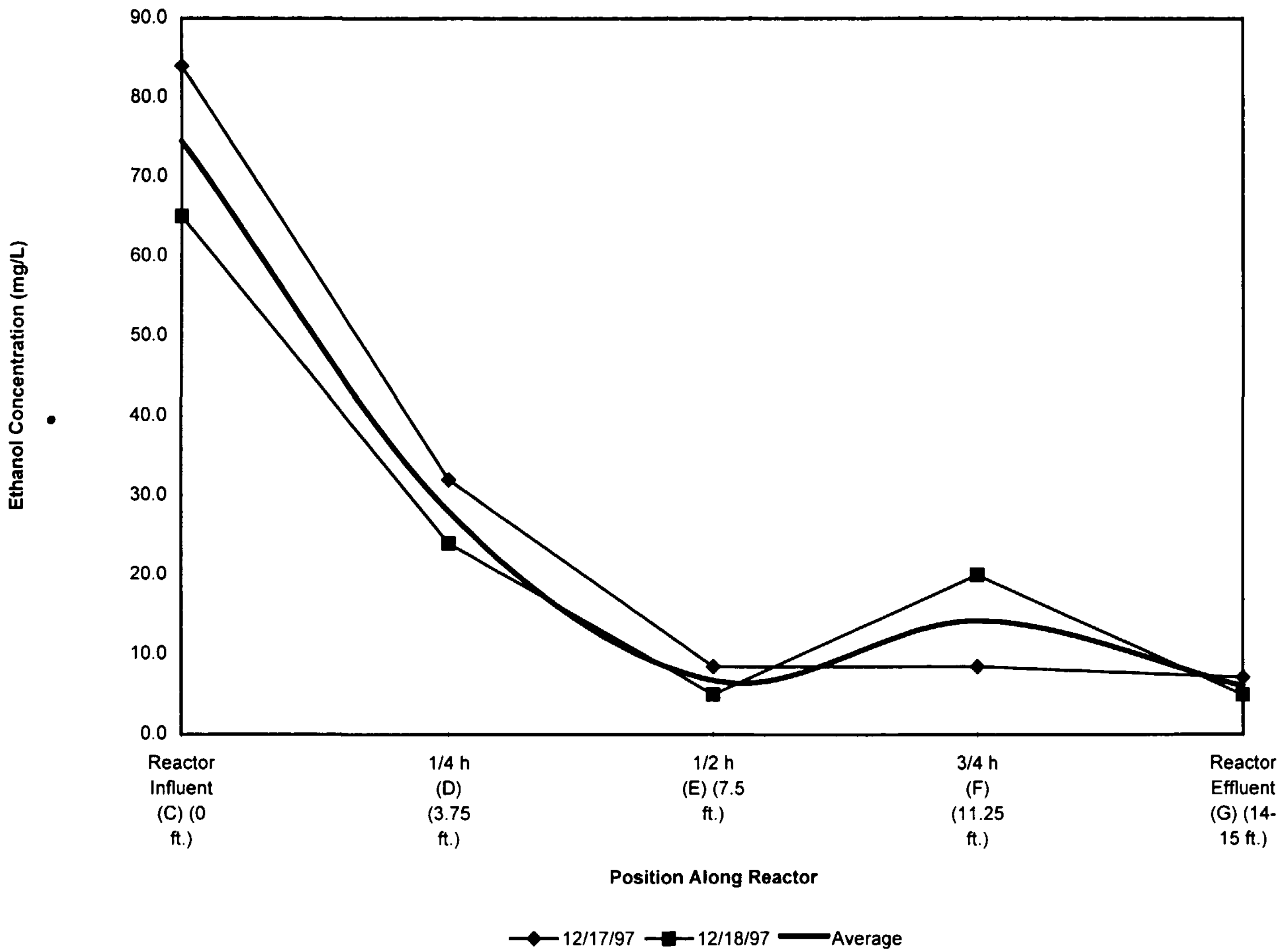
ETHANOL REACTOR PROFILES
INFLUENT DO RANGE (0.5 - 1.3 mg/L), 17% RECIRCULATION
Phase I Perchlorate Treatability Study

PLATE 13

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	



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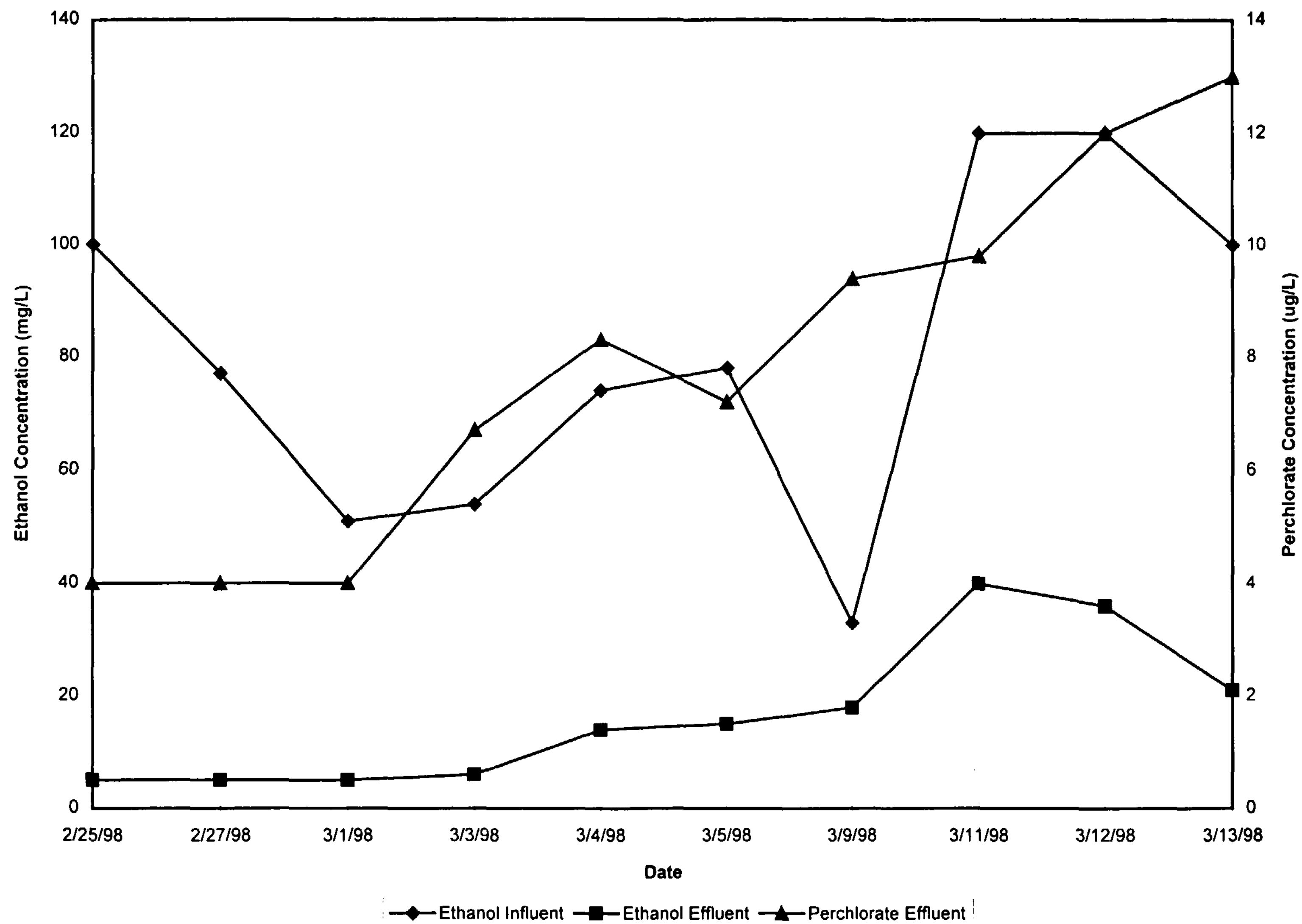
ETHANOL REACTOR PROFILES
INFLUENT DO RANGE (8.3 - 8.5 mg/L),
0% RECIRCULATION
Phase I Perchlorate Treatability Study

PLATE **14**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	39860-355		5/98	

R14 PLOT 1 = 1 TO 4MV HOT\39860\355\598T16



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HLA	**Harding Lawson Associates** Engineering and Environmental Services		**ETHANOL INFLUENT/EFFLUENT vs. PERCHLORATE EFFLUENT** **ETHANOL OPTIMIZATION STUDY** *Phase I Perchlorate Treatability Study*	PLATE **15**
DRAWN JTL	PROJECT-TASK NUMBER 39860-355	APPROVED	DATE 5/98	REVISED DATE

TABLES

Table 7-1
Sampling and Analysis Plan
System Startup Period (Week 1)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	1/week					1/week	4
Alcohols			7/week				7/week	14
Perchlorate			7/week				7/week	14
Chlorate, Chlorite, Hypochlorite			1/week					1
Alkalinity (carbonate, bicarbonate)			1/week					1
Chloride			1/week					1
Total Phosphorus			1/week					1
Nitrogen, Ammonia			7/week				7/week	14
Nitrogen, Nitrate, Nitrite			7/week				7/week	14
Sulfate, sulfide			1/week					1
Metals[1]			1/week					1
Bacteriology[2]			1/week				1/week	2
Total Dissolved Solids			1/week					1
Total Suspended Solids			1/week					1
Turbidity			1/week					1
Biochemical Oxygen Demand			1/week					1
Chemical Oxygen Demand			7/week				7/week	14

1 Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
2 Total and fecal coliform and heterotrophic plate count

Table 7-2
Sampling and Analysis Plan
System Startup Period (Week 2)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	2/week	2/week					2/week	6
Alcohols			7/week	7/week	7/week	7/week	7/week	35
Perchlorate			7/week	7/week	7/week	7/week	7/week	35
Chlorate, Chlorite, Hypochlorite			7/week	7/week	7/week	7/week	7/week	35
Alkalinity (carbonate, bicarbonate)			2/week				2/week	4
Chloride			7/week	7/week	7/week	7/week	7/week	35
Total Phosphorus			7/week				7/week	14
Nitrogen, Ammonia			7/week	7/week	7/week	7/week	7/week	35
Nitrogen, Nitrate, Nitrite			7/week	7/week	7/week	7/week	7/week	35
Sulfate, sulfide			2/week				2/week	4
Metals[1]			2/week				2/week	4
Bacteriology[2]			2/week				7/week	9
Total Dissolved Solids			2/week				2/week	4
Total Suspended Solids			2/week				2/week	4
Turbidity			2/week				2/week	4
Biochemical Oxygen Demand			2/week				2/week	4
Chemical Oxygen Demand			7/week	7/week	7/week	7/week	7/week	35

1 Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
2 Total and fecal coliform and heterotrophic plate count

Table 7-3
Sampling and Analysis Plan
Performance Monitoring Period (Weeks 3 through 8)

Analytes	Air Stripper Influent	Air Stripper Effluent	GAC/FB Influent	GAC/FB 1/4	GAC/FB 1/2	GAC/FB 3/4	GAC/FB Effluent	Total Samples
Volatile Organic Compounds	1/week	1/week					1/week	18
Alcohols			7/week	1/week	1/week	1/week	7/week	102
Perchlorate			7/week	1/week	1/week	1/week	7/week	102
Chlorate, Chlorite, Hypochlorite			1/week				1/week	12
Alkalinity (carbonate/bicarbonate)			1/week				1/week	12
Chloride			1/week				1/week	12
Total Phosphorus			1/week				1/week	12
Nitrogen, Ammonia			1/week				1/week	12
Nitrogen, Nitrate, Nitrite			7/week	1/week	1/week	1/week	7/week	102
Sulfate			1/week				1/week	12
Metals[1]			1/week				1/week	12
Bacteriology[2]			1/week				1/week	12
Total Dissolved Solids			1/week				1/week	12
Total Suspended Solids			1/week				1/week	12
Turbidity			1/week				1/week	12
Biochemical Oxygen Demand			1/week				1/week	12
Chemical Oxygen Demand			1/week				1/week	12

1 Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
2 Total and fecal coliform and heterotrophic plate count

Table 7-4
Analytical Method Requirements

Analytes	U.S. EPA Method	Preservative	Holding Time	Sample Container	Sample Volume	Method Detection Limit	Reporting Limit
Volatile Organic Compounds	8260	HCL-pH<2	14 days	40 ml VOA	3 x 40 mL	Varied	5 - 100 µg/L
Alcohols	8015	4°C	14 days	40 ml VOA	1 x 40 mL	Varied	100 mg/L
Perchlorate	300 (modified)	Cool 4°C	14 days	Poly	125 mL	2 ppb	5 ppb
Chlorate, Chlorite, Hypochlorite	300	4°C	14 days	Poly	100 mL	Still being determined	200,20,50 ppb
Alkalinity (carbonate/bicarbonate)	310.1	4°C	14 days	Poly	500 mL	---	5 mg/L ppm
Chloride	325.2	4°C	28 days	Poly	50 mL	0.72 ppb	1.0 mg/L ppm
Total Phosphorus	365.5	H_2SO_4	28 days	Poly	100 mL	0.04 ppb	0.3 mg/L ppm
Nitrogen, Ammonia	350.1	H_2SO_4	28 days	Poly	100 mL	0.027 ppb	0.1 mg/L ppm
Nitrogen, Nitrate, Nitrite	353.1	4°C	28 days	Poly	100 mL	0.0044 ppb	0.1 mg/L ppm
Sulfate, Sulfide	375.4	Cool 4°C	Sulfate - 28 days Sulfide - 7 days	Poly	100 mL	---	1.0 mg/L ppm
Metals[1]	6000/7000	HNO_2 - pH<2	6 months	Poly	500 mL	Varied	Varied
Bacteriology[2]	9200	Sodium Thosulfate - 4°C	24 hours	Plastic	100 mL	Varied	Varied
Total Dissolved Solids	160.1	4°C	7 days	Poly	100 mL	---	10 mg/L ppm
Total Suspended Solids	160.2	4°C	7 days	Poly	500 mL	---	5 mg/L ppm
Turbidity	180.1	4°C	2 days	Poly	50 mL	---	1 NTU
Biochemical Oxygen Demand	405.1	4°C	2 days	1L Amber	1,000 mL	---	3.0 mg/L
Chemical Oxygen Demand	410.4	HNO_2 - pH<2	28 days	Poly	50 mL	8.9 ppb	10 mg/L

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

Table 7-5
Field Quality Control Sample Schedule
(Total Samples)

		Week 1		Week 2		Week 3		
Analytes	**U.S. EPA Method**	**Splits**	**Blanks**	**Splits**	**Blanks**	**Splits**	**Blanks**	**Total Samples**
Volatile Organic Compounds	8260		2 (T)	1	1 (T)	2	3 (T)	9
Alcohols	8015	1		2	1 (T)	6	3 (T)	13
Perchlorate	300 (modified)	1		2	1 (F)	6	3 (F)	13
Chlorate, Chlorite, Hypochlorite	300			2		1		3
Alkalinity (carbonate/bicarbonate)	310.1			1		1		2
Chloride	325.2			2		1		3
Total Phosphorus	365.5			2		1		3
Nitrogen, Ammonia	350.1	1		2		1		4
Nitrogen, Nitrate, Nitrite	353.1	1		2		6		9
Sulfate, Sulfide	375.4			1		1		2
Metals[1]	6000/7000			1		1		2
Bacteriology[2]	9200			2		3		5
Total Dissolved Solids	160.1			1		1		2
Total Suspended Solids	160.2			1		1		2
Turbidity	180.1			1		1		2
Biochemical Oxygen Demand	405.1			1		1		2
Chemical Oxygen Demand	410.4	1		2		1		3

T = Trip Blank F = Field Blank

1 Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
2 Total and fecal coliform and heterotrophic plate count

Table 7-6
Laboratory Quality Control Procedures

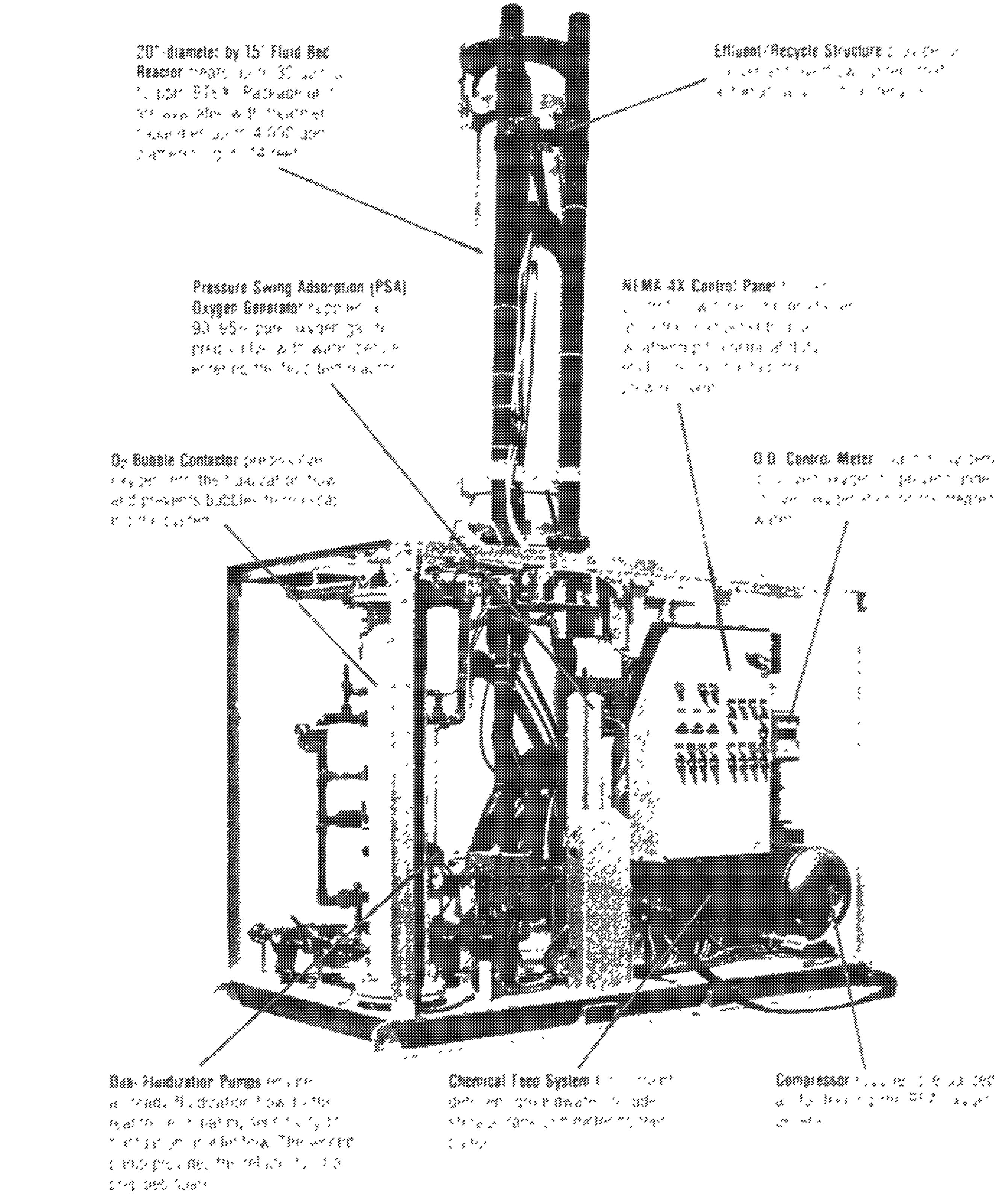
Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Volatile Organic Compounds	8260	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	60-140	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Alcohols	8015	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	50-150	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Perchlorate	300 (modified)	5 points	Every 10 samples	Every 10 samples and after last sample	Less than MDL	1 per batch	70-130	1 per 20 samples	±20	1 per 20 samples	85-115	1 per 20 samples
Chlorate, Chlorite, Hypochlorite	300	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	50-150	1 per 20 samples
Alkalinity (carbonate/bicarbonate)	310.1	6 points	Every 10 samples	---	<R.L.	1 per batch	---	---	---	---	---	---
Chloride	325.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±30	1 per 20 samples	60-140	1 per 20 samples
Total Phosphorus	365.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	60-140	1 per 20 samples
Nitrogen, Ammonia	350.2	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Nitrogen, Nitrate, Nitrite	353.3	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples

Analytes	U.S. EPA Method	Initial Calibration	Continuing Calibration	Standard	Method Blank		Matrix Spike		Matrix Spike Duplication		Laboratory Control Sample	
					Control Limit	Minimum Frequency	Control Limit (%R)	Minimum Frequency	Control Limit (RFD)	Minimum Frequency	Control Limit (%R)	Minimum Frequency
Sulfate	375.4	6 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	70-130	1 per 20 samples
Metals[1]	6000/7000	3 points	Every 10 samples	---	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	50-150	1 per 20 samples
Bacteriology[2]	9221B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Dissolved Solids	160.1	---	---	---	<R.L.	1 per patch	---	---	---	---	---	---
Total Suspended Solids	160.2	---	---	---	<R.L.	1 per batch	---	---	---	---	---	---
Turbidity	180.1	---	---	---	---	---	---	---	---	---	---	---
Biochemical Oxygen Demand	405.1	N/A	N/A	N/A	<0.2	1 per batch	---	---	---	---	---	---
Chemical Oxygen Demand	410.4	6 points	Every 10 samples	Every 10 samples	<R.L.	1 per batch	25-125	1 per 20 samples	±25 or 30	1 per 20 samples	---	1 per 20 samples

N/A = Not Applicable

[1] Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
[2] Total and fecal coliform and heterotrophic plate count

FIGURES



REFERENCE: CONTRACTOR EQUIPMENT BROCHURE

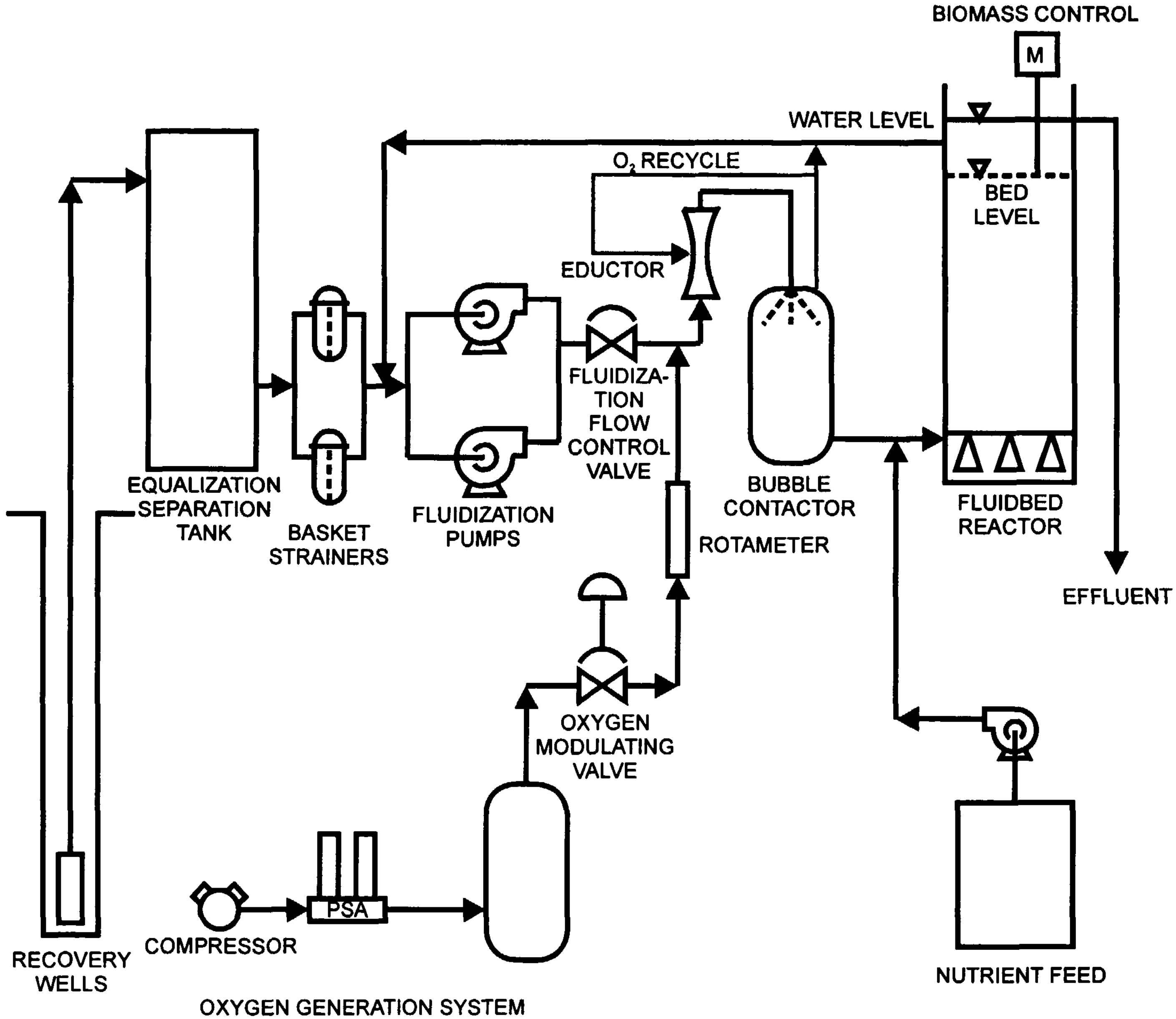
Harding Lawson Associates
Engineering and
Environmental Services

PHOTOGRAPH
Typical Contractor GAC/FB Pilot Unit

FIGURE
5-1

JTL 3/933-003 8/87

HDT\37933\003\PID

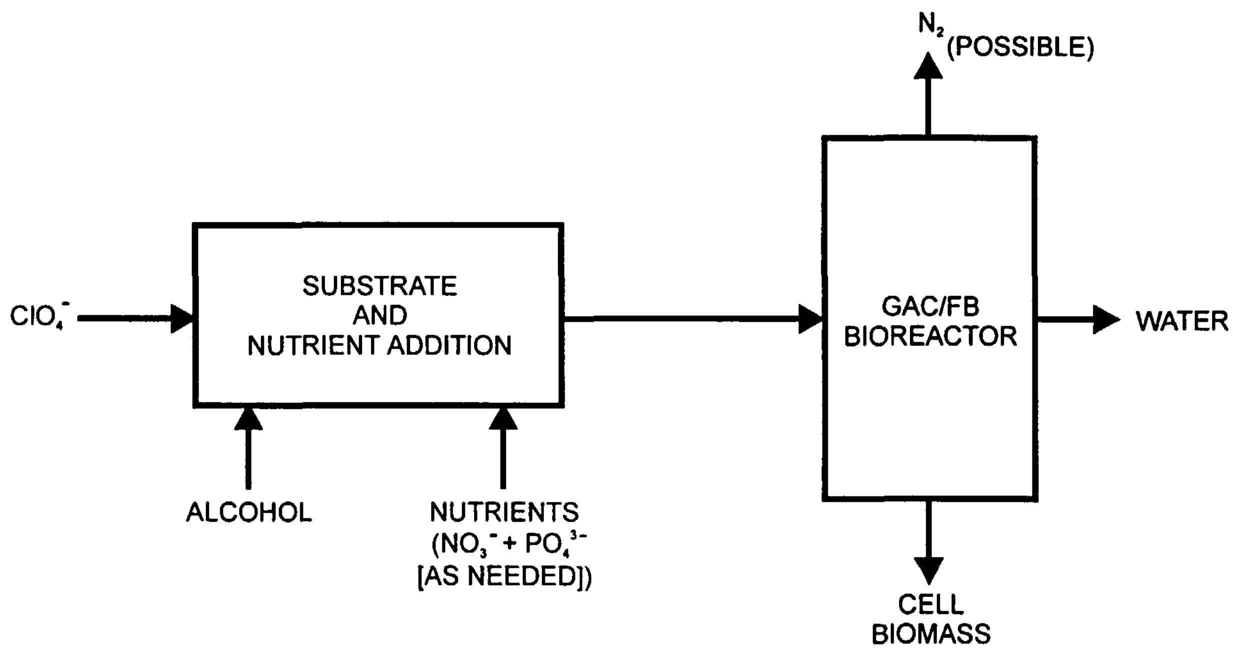


Harding Lawson Associates
Engineering and Environmental Services

TYPICAL CONTRACTOR PROCESS AND INSTRUMENTATION DIAGRAM

FIGURE **5-2**

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	37933-003		8/97	



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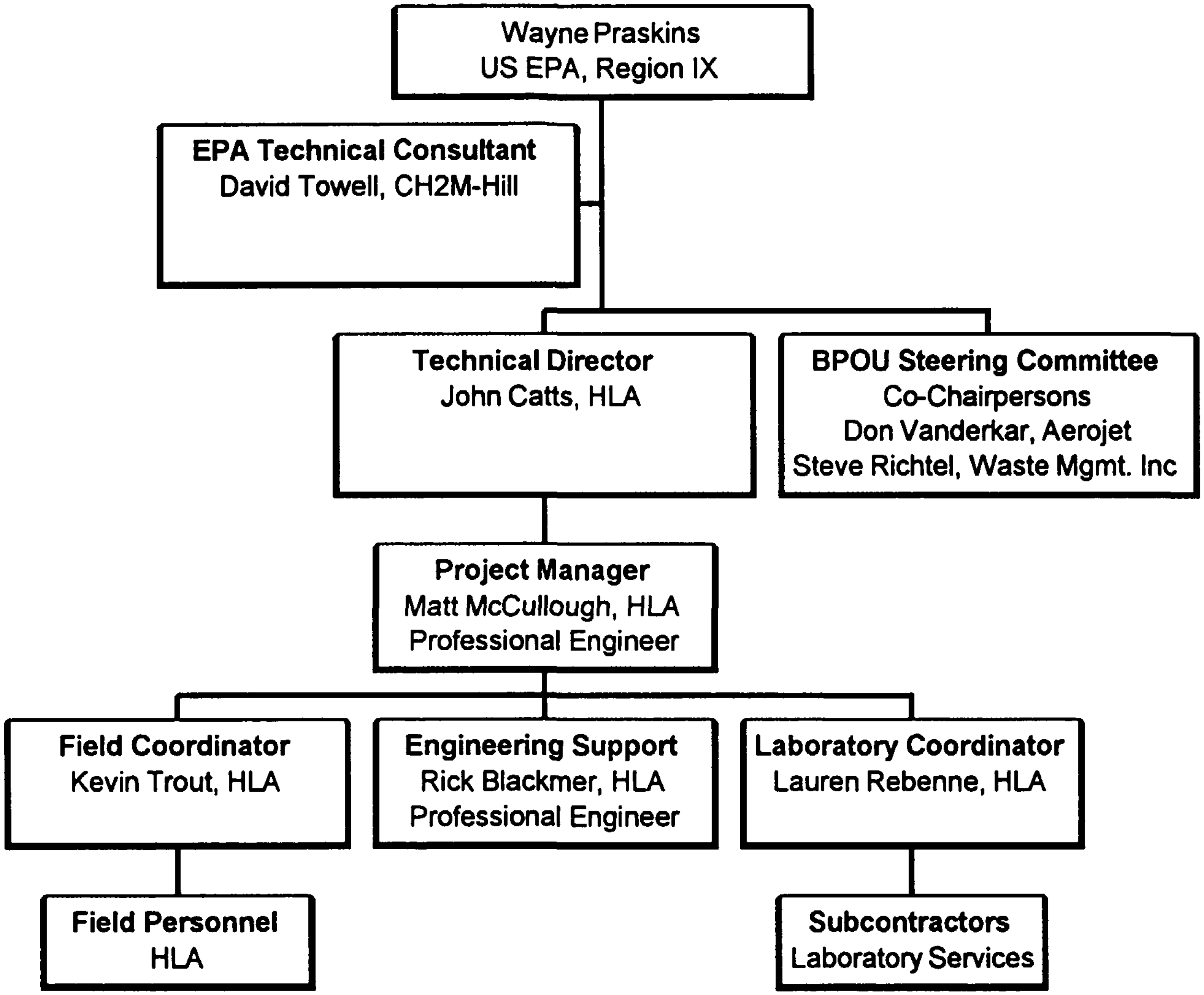
IDEALIZED MASS FLOW DIAGRAM -
BIOCHEMICAL PERCHLORATE REDUCTION

FIGURE 5-3

DRAWN	PROJECT-TASK NUMBER	APPROVED	DATE	REVISED DATE
JTL	37933-003		8/97	

Figure 9-1. Implementation Team



APPENDIX A

REVISED FINAL PHASE I TREATABILITY STUDY WORK PLAN

FILE COPY

REVISED FINAL
Phase I Treatability Study Work Plan
Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Prepared for

Baldwin Park Operable Unit Steering Committee

HLA Project No. 37933 003

John G. Catts, Ph.D.
Vice President
Chief Technical Officer

Matthew L. McCullough, P.E.
Vice President

November 7, 1997

HLA

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Harding Lawson Associates

November 7, 1997

37393 003

Mr. Wayne Praskins
United States Environmental Protection Agency
Project Manager
75 Hawthorne Street
San Francisco, California 94105-3901

Revised Final Phase I Treatability Study Work Plan, Perchlorate in Groundwater
Baldwin Park Operable Unit
San Gabriel Basin

Dear Mr. Praskins:

On behalf of the Baldwin Park Operable Unit Steering Committee (BPOUSC), Harding Lawson Associates (HLA) is submitting the attached "Revised Final Phase 1 Treatability Study Work Plan, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin". We have revised the Final Phase 1 Treatability Work Plan dated October 6, 1997 to address EPA comments provided in letters dated September 12, 1997 and October 16, 1997. We have also revised the Work Plan to reflect changes to the treatment plant configuration that were made during the design and construction stage of the project, and refined the description of startup, sampling, and analysis procedures.

The following are responses to your comments on the Work Plan. Each U.S. EPA comment is repeated below with citation to the page/column/section (e.g. 3/2/2.3) to which you referred. This comment is followed by the BPOUSC response.

Comment: 3/2/2.3	*Please identify the "higher than normal level of quality control precautions" that will be taken.*
Response:	Since the date that the Draft Work Plan was first issued, additional commercial laboratories have received approval for analysis of perchlorate in water. In addition the BPOUSC, in sampling BPOU monitoring wells, sent split samples to multiple laboratories. Results indicate precision in line with other analytical methods. Therefore the language present in the Draft Work Plan has been removed. Details on laboratory and field quality control procedures are now contained in the text of the Work Plan, Table 7.5, and Table 7.6.
Comment: 7/2/4.2	***Please specify the perchlorate concentration or concentration range that is "representative of that anticipated in San Gabriel Basin."***
Response:	Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the concentration of perchlorate in groundwater extracted by the BPOU project, is expected to range between 50 and 100 ug/L. The well at Aerojet's Sacramento facility which will provide treatment plant influent will contain approximately 50 ug/L perchlorate. This is stated in the text.

Comment: 7/2/4.3 — *We understand that biological denitrification has been used directly on a drinking water system in France in a 5 MGD system, and indirectly on a drinking water supply in El Paso, Texas.*

Response: The workplan text has been modified to include reference to this information.

Comment: 8/1/4.3 — *Please specify the nitrate concentration or concentration range that is "similar to that expected in San Gabriel Basin."*

Response: Based on available water quality data, modeling performed to support extraction system design, and assumptions regarding the location, construction, and production of future extraction wells, the nitrate concentration in groundwater extracted by the BPOU project is expected to range between 20 and 25 ug/L. The well selected to provide treatment plant influent will contain between 50 and 70 mg/L nitrate. This is stated in the text.

Comment: 8/1/4.5 — *We expect that phase 2 testing can begin earlier than April 1998. As explained in the EPA letter dated 8/28/97, we expect that the Steering Committee will submit the following documents within 75 calendar days of EPA approval of the workplan: a written phase 1 progress report for treatability testing of the biological process that includes a description of and schedule for the remaining phase 1 testing and either: (I) a supplemental workplan for phase 2 treatability studies; or (ii) a detailed explanation why additional phase 1 testing is necessary before preparation of a phase 2 workplan and planned submittal date for the phase 2 workplan.*

We agree with the narrative on page 8 (Section 4.5) and page 13 (Section 10.0), but believe that tasks planned for completion after 11/27/97 can be finished and submitted earlier. Specifically, we believe that in the absence of unforseen difficulties during pilot-scale testing, "Phase 1 testing" can be completed before 12/27/97. We also believe that "Draft Phase 1 Report" can be submitted well before 2/25/98. The proposed schedule allows an unnecessarily lengthy 6 1/2 weeks after the end of testing for report preparation.

We assume that the last two dates provided in Section 10.0 are in 1998, not 1997.

Response: The BPOUSC will comply with the project reporting requirement presented in EPA's letter dated August 28, 1997. The text of Section 10.0 has been modified accordingly.

Although U.S. EPA has communicated in writing (October 16, 1997) and orally (October 22,1997) the belief that Phase 1 testing can be completed before 12/27/97, and that a draft Phase 1 report can be prepared before 2/25/97, the U.S. EPA and the BPOUSC agreed in a meeting on October 22, 1997 that following receipt of the November 27, 1997 written progress report both parties would review progress made and revise the schedule accordingly. The BPOUSC will certainly work diligently to accomplish tasks as rapidly as possible, and look for ways to reduce the schedule for report preparation.

The last two dates in Section 10.0 were incorrectly reported as 1997 and have been revised to 1998.

Comment: 8/2/4.5

One of the objectives listed for phase 2 is to evaluate the relative bacterial preference for perchlorate and nitrate. The treatability study should examine other parameters relevant to microbially-catalyzed oxidation-reduction reactions, including the presence and depletion of competing electron acceptors. Measurement of these parameters may provide information that can be used to optimize removal rates, reduce operating costs, and diagnose the cause of lower than expected perchlorate removal rates. These processes are commonly examined during evaluations of biological degradation and natural attenuation in groundwater (e.g., see Technical Protocol for Natural Attenuation of Chlorinated Solvents in Groundwater, by T.H. Wiedemeier et. Al.).

Parameters commonly measured during studies of biological degradation and natural attenuation include:

- *iron II (Fe^{+2}) - reaction product for competing redox reaction (iron reduction)*
- *sulfate and sulfide - competing electron acceptor and reaction product (sulfate reduction)*
- *methane - reaction product for competing redox reaction (methanogenesis)*
- *oxidation-reduction potential - indicator of type of redox reactions that may occur.*

Consideration should also be given to measurement of additional chlorine compounds, and preparation of a mass balance of all chlorine species, in order to determine whether the perchlorate is fully reduced to chloride. Other possible chlorinated products include chlorate, chlorite, and hypochlorite.

Text and Tables in revised workplan include measurement or analysis of sulfate, redox potential, chlorate, chlorite, and hypochlorite. Sulfide is not mentioned in the text, but included in Tables 7.1 and 7.3. Fe+2 and methane are not mentioned in the text or Tables.

Response:

The BPOUSC will examine the presence and effect of competing electron acceptors in Phase 2 treatability testing. To the extent possible data to support this evaluation will be collected and interpreted during Phase 1 treatability testing. Specifically redox potential and dissolved oxygen will be measured in the field and on select samples perchlorate/chlorate/chlorite/hypochlorite/chloride, sulfate/sulfide, and nitrate/nitrite will be measured. These parameters will be measured during the initial start up period and the performance monitoring period in accordance with Tables 7.1, 7.2, and 7.3.

Iron (II) and methane will not be measured during Phase 1 testing. Concentrations of iron in groundwater in both Sacramento and San Gabriel Basin are expected to be low. Analysis for iron (II) is most commonly performed using a colorimetric field technique with a high reporting limit. Therefore iron (II) concentrations will likely be less than this reporting limit. Should metals analysis performed during the initial source water analysis result in total iron concentrations that suggest iron (II) would be measurable, analysis for iron (II) will be reconsidered.

Samples for the analysis of methane will not be collected because based on the slightly reducing (anoxic) conditions observed during past pilot-scale testing measurable concentrations of methane are not expected. In addition it will not be possible to collect a meaningful and representative sample from the GAC/FB bioreactor which is not a pressurized system and is open to the atmosphere.

Throughout the treatability study, analytical test results will be evaluated to determine whether they are providing meaningful information. Tests that are providing meaningful information will be continued; however, some analytical testing may be discontinued if these tests are not providing meaningful data.

Comment: Figure 5-1 *The photograph of the pilot unit shows an air compressor, oxygen generator, bubble contactor, and dissolved oxygen control meter. Presumably, these will not be used during the treatability study.*

Response: The photograph of the pilot unit was provided by the vendor. This photograph includes system components that may or may not be used in this pilot study. Specifically the GAC/FB bioreactor will not contain an air compressor, oxygen generator, or bubble contactor. In line meters, placed in the bioreactor influent and effluent lines will measure dissolved oxygen, pH, redox potential, and temperature.

Comment: Figure 5-2 *The Process and Instrumentation Diagram also shows an Oxygen Generation System and recycling line. Please correct the diagram or explain the need for this equipment. Also, please add other system components described elsewhere in the workplan (e.g., air stripper, filters, effluent pumps, recycle line, backwash line, backwash pumps, effluent equalization tank, 20,000 gallon storage tank, sample ports).*

Please provide a schematic showing the relationship between major system components. Describe the purpose of any components not discussed in the text. If preferred, provide as separate document.

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit is a general P&ID and was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study.

A schematic showing major system components is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

Comments: 8/2/5.0 *Should tests also be conducted in reverse order: through the biological unit first, followed by air stripping? Isn't the biological process likely to remove some of the VOCs, offering the potential to reduce air stripping and/or offgas control costs?*

Response: Under our current schedule, we do not anticipate any time will be available to reverse the order of unit operations. The current system configuration was selected because we wished to focus solely on perchlorate and nitrate treatment and because of a concern that flow of water containing VOCs through the bioreactor would remove some VOCs but that others would be recalcitrant, and that vinyl chloride, a VOC that is not captured effectively by vapor phase carbon, may formed. At the conclusion of our planned testing, we will evaluate and prioritize what further testing is necessary. This has been addressed in the Work Plan in Sections 5.0 and 10.0.

Comment: 9/2/5.0 *Will the methanol in denatured alcohol limit the end use of the water? Should methanol be analyzed for in the effluent?*

Water temperature should be measured, given the potential temperature dependence of reaction rate. If the water temperature in the reactor may be cooler than San Gabriel basin groundwater (as implied by need for heat tracing on the filtration line), should water temperature be adjusted?

The text describes the effluent being discharged into a 550 gallon equalization tank. Is this tank for solids removal?

Figure 5-2 shows an equalization separation tank on the influent line. What is the purpose of this tank?

"Alcohol" specified as carbon source/electron donor in revised workplan. Possible impact of methanol not discussed.

Need for water temperature adjustment not discussed.

Purpose of equalization tanks (2) not discussed.

Response: Treated water will ultimately have to be acceptable for potable use. Based on past treatability studies neither methanol or ethanol are expected in the effluent. This is in fact a goal of the treatability study, to minimize alcohol addition so that perchlorate reduction is maximized but residual substrate (alcohol) and nutrients are minimized. To ensure this goal is achieved water quality analysis for ethanol and methanol will be performed as described in Section 7.0. Analytical reporting limits for these chemicals and all other chemicals of concern, as shown in Table 7.4, are below available health based standards for water intended for potable use.

As described in Section 7.1 water temperature will be measured during treatability testing; however, no adjustment in water temperature is planned. We anticipate that extracted groundwater temperature will be fairly constant based upon previous test data. Some precautions will be taken to ensure that cold weather does not affect system operations. These precautions are described in Section 5.0. During previous treatability testing of this technology, performed from April through December, water temperature varied less than 2 degrees centrigrade. With respect to comparison between Sacramento and San Gabriel Basin, groundwater temperature in Sacramento generally varies between 18 to 22 degrees centigrade averaging approximately 20 degrees, while the temperature of groundwater in San Gabriel Basin generally varies from 10 to 28 degrees centigrade averaging approximately 22 degrees.

Based on changes made to system configuration during design and construction activities the equalization tank on the influent line has been eliminated. There is a 70 gallon reservoir in the base of the air stripper that with appropriate sensors will serve to assure a constant flow rate to the fluidized bed.

The 500 gallon effluent equalization tank will be used to assure a constant flow through the pump which sends treated water back to the GET-B system. Contrary to previous discussions, the GAC/FB bioreactor has an internal recycle system and the equalization tank is therefore not needed for this purpose. The text of Section 5.0 has been revised to reflect these changes and provide additional clarification.

Comment: 10/2/6.1 *Should the expected organic loading rate reflect the difference in perchlorate concentration between Sacramento and Baldwin Park?*

The workplan states that "targeted analytical parameters will be measured after each change of operating conditions." How long is needed for stabilization - minutes or hours? Perhaps a parameter vs. Time curve should be generated to determine the optimal time for sample collection after a change in operational conditions.

Response: The extraction well selected as the source water will yield water with perchlorate and nitrate concentrations similar to that expected in San Gabriel Basin (Sections 4.2 and 4.3). The organic substrate will be initially added to the influent at a rate that was recommended as a result of previous treatability testing. This was a recommendation for addition of alcohol to perchlorate at a molar ratio of 4:1. The expected perchlorate concentrations will be significantly lower than encountered during previous testing and nitrate concentrations are expected to be significantly higher than encountered during previous testing. Therefore the initial alcohol loading rate will be set at a ratio of 4:1 based molar concentrations of perchlorate plus nitrate.

Reactor stability will be investigated as part of the treatability study. Although it is expected that the reactor will respond relatively rapidly to changes in operating conditions, approximately 24 hours will be allowed for stabilization after an influent change. At this time samples will be collected and analyzed and data interpreted before additional operating parameters are changed. This approach is described in the workplan in Sections 6.1 and 7.2. These data will allow plots of parameter vs. time.

Comment: 11/1/7.1 *The workplan states that DO concentrations in the influent and effluent of the GAC/FB system will be monitored daily. We assume that these measurements will be made at sample ports located on the influent and effluent lines immediately adjacent to the reactor vessel. Please show the locations of the recycle line and sample ports on Figure 5-2.*

Project-specific schematic not provided.

Response: The Process and Instrumentation Diagram (P&ID) for the pilot unit, as shown in Figure 5-2, was provided by the vendor. This P&ID includes system components that may or may not be used in this pilot study and does not detail sample port locations. During bioreactor construction sampling valves that withdraw water from the influent and effluent lines will be added and sampling devices that withdraw water from positions that are approximately 25 %, 50 %, and 75 % through the reactor flow path will be added.

A project specific schematic is not provided in the Work Plan. This request will be addressed by Aerojet in a separate letter.

Comment: 11/2/7.2 *The source water for the treatability testing should be sampled for anions, metals, general water chemistry, and other parameters that might affect system performance.*

Why collect the effluent ethanol samples as composites rather than grab samples?

Analysis of source water not specifically addressed. Will "GAC/FB influent" be identical to source water ?

Comments requesting explanation for collection of composite samples not addressed.

Response: The influent and effluent will be tested for a wide range of water quality parameters including appropriate parameters from the California Code of Regulations (CCR), Title 22, common cations, common anions, and metals. At least one sample of influent (source water) will be collected and analyzed during the initial system startup. In addition weekly samples of influent and effluent will be collected and tested for the duration of the performance monitoring period.

All samples will be gathered as grab samples. In the Draft Work Plan the only composite samples to be collected were from the effluent equalization tank, with all other samples collected as grabs. The rationale for collecting composite samples from this tank was to obtain an integrated composition of this water prior to discharge to the ground surface. Now that treated water is to be discharged directly to the GET-B treatment system these composite samples will not be needed. The text of Section 7.2 has been revised accordingly.

Comment: 12/1/7.3	*The list of analytes should include parameters mentioned in the comment on page 8, column 2, section 4.5.* *See earlier comment.*
Response:	Section 7.0 and associated tables have been modified in accordance with this comment.
Comment: 12/2/10.0	*The schedule should be modified as explained in the comment on page 8, column 1, section 4.5.* *See earlier comment.*
Response:	The schedule as described in Section 10.0 has been modified in accordance with this comment.
Comment: 8/2/5.0	*How likely is it that an additional treatment step will be needed to remove residual alcohol ?*
Response:	Past treatability testing using this technology produced effluent that did not contain detectable concentrations of alcohol. It is the objective of this testing to optimize reactor performance such that effluent does not contain measurable alcohol. The detection limits for these and other parameters as shown on Table 7.3 are below health based concentrations suitable for unrestricted consumption (potable).
Comment: 9/2/5.0	*Why is filtration no longer believed to be needed ?* *Why does the workplan no longer specify a 20,000 gallon backup tank for discharge of effluent, or a recycle line ?*
Response:	Filtration is no longer needed as effluent from the treatment system will be discharged to the GET-B treatment system. Testing and selection of a suitable filtration system will be performed during Phase 2 treatability testing. The 20,000 gallon tank is no longer needed. Effluent was to be retained in this tank and tested prior to discharge to the ground surface. Now effluent will be pumped directly to the GET-B treatment system, and therefore storage capacity is not needed.
Comment: 10/2/6.3	*The text states that approximately 5 % of all samples will be collected as splits. How will these samples be chosen ? Will these analyses be in addition to the duplicates listed in Table 7.2 ?* *The text also states that field blanks, equipment blanks, and trip blanks will be submitted daily or weekly. Is this correct?*

Response: The duplicate samples previously shown on Table 7.2 are the split samples that will be collected at a minimum frequency of 5 %. To clarify this issue field quality control samples are now shown separately in Table 7.5.

The text has been revised to state that field quality control samples that will be collected will include sample splits (duplicates), and trip blanks. Field blanks and equipment blanks are not appropriate for this treatability test and have therefore been deleted.

Comment: 12/1/8.0 *Please describe the process for obtaining Regional Water Quality Control Board approval for discharge of treated water.*

Response: Effluent from this treatability test will be pumped to the GET-B. Therefore additional discharge approval specifically for this treatability test is unnecessary. Earlier drafts of the Work Plan planned for discharge to the ground surface, but this protocol was modified with the knowledge of the Regional Water Quality Control Board.

Comment: 13/1/10.0 *Did DHS or MWD review the workplan, as described in the schedule ?*

Response: Both DHS and MWD were sent a copy of the Work Plan , but to date no comments have been received.

Comment: Table 7.3 *The MDL for perchlorate appears to be incorrectly reported as 28 ug/L.*

Response: Both the Method Detection Limit and the Reporting Limit for perchlorate were incorrectly reported in Table 7.4. This table has been revised.

Should you have questions regarding this Work Plan or the treatability testing that is in progress, please do not hesitate to call Don Vanderkar at (916) 355-4282, John Catts at (415) 899-8825, or Matt McCullough at (714) 260-1800.

Sincerely,

HARDING LAWSON ASSOCIATES

FOR:

John G.Catts, Ph.D.
Chief Technical Officer

Matthew McCullough P.E.
Vice President

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CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

For the past several years the Baldwin Park Operable Unit Steering Committee (BPOUSC), the U.S. EPA Region IX (U.S. EPA), Three Valleys Municipal Water District (TVMWD), and the Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of U.S. EPA to remediate a plume of volatile organic compounds (VOCs) in groundwater in the Cities of Azusa and Baldwin Park. This plume is distributed from locations north of Interstate 210 in the City of Azusa southwest to locations in the vicinity of Interstate 10 in the City of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU).

The BPOUSC was in the process of negotiating agreements for the project with the U.S. EPA, MWD, and TVMWD when in June 1997 concentrations of perchlorate ion, above the State of California Department of Health Services (DHS) provisional action level of 18 μg/L, were found in BPOU groundwater. Before the project can move forward, the potential impact that perchlorate has on the conceptual project design must be evaluated. Perchlorate in BPOU groundwater is particularly troublesome since there is no treatment technology that has been demonstrated to be effective in reducing concentrations of perchlorate to the provisional action level.

Treatability testing at a pilot-scale has been successfully performed at the Aerojet General Corporation (Aerojet) facility near Sacramento, California. The technology can be described as a biochemical reduction process using a fixed film bioreactor. The fixed film is attached to granular activated carbon operated as a fluidized bed (GAC/FB). This pilot-scale test demonstrated that the technology was effective in treating perchlorate in groundwater.

There are however several important differences between objectives of this previous pilot-scale work and current objectives for the BPOU project. First, the flow rate was 0.1% of that needed in San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in San Gabriel Basin. Third, the pilot system was not designed to achieve nor did it achieve effluent perchlorate concentrations less than 18 μg/L provisional action level. Finally, the previous testing was not designed to deliver potable water.

The purpose of this Work Plan is to describe the approach and methods that will be used in performing pilot-scale treatability testing of the GAC/FB biochemical reduction technology specifically for application in San Gabriel Basin. The pilot-scale testing will be performed in two phases. In the first phase the objective is to assess if the chosen technology can achieve the target effluent goal. In the second phase, scientific and engineering data needed to design and construct a full-scale treatment system will be collected.

Although this GAC/FB treatment technology has shown the potential to treat perchlorate at concentrations present in San Gabriel groundwater, other treatment technologies may also be applicable. The BPOUSC is in the process of completing a technology screening to assess the viability of other treatment technologies and make recommendations regarding bench-scale and pilot-scale testing if appropriate.

2.0 HISTORY OF PERCHLORATE ISSUES

In February 1997 perchlorate was discovered in five drinking water supply wells in Sacramento, California. This discovery was a result of the recent improvement in the method of perchlorate analysis which has only allowed detection of perchlorate in water at concentrations below the level which EPA and DHS considers acceptable for use by the public (18 μg/L) since early 1997. The detection of perchlorate in Sacramento water supply wells led DHS to perform sampling and analysis of groundwater for perchlorate in other portions of the state including San Gabriel Basin.

2.1 Distribution of Perchlorate in the BPOU

Perchlorate was first detected in San Gabriel Basin groundwater in June 1997 by DHS. This prompted the Main San Gabriel Basin Watermaster (MSGBWM) and the BPOUSC to perform additional groundwater sampling and analysis to better understand the distribution of perchlorate in groundwater.

To date, the BPOUSC has compiled perchlorate data for over 50 monitoring wells, production wells, and sampling points in the vicinity of the BPOU. Perchlorate analysis for production wells was performed on samples obtained by the DHS and MSGBWM and provided by the San Gabriel Basin Water Quality Authority (SGBWQA). Groundwater samples from monitoring wells in the BPOU were collected by Camp Dresser McKee, Harding Lawson Associates, and Geosyntec on behalf of the BPOUSC.

The lateral and vertical distribution of perchlorate in groundwater has been previously described (see "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997a], "Final Addendum to Sampling and Analysis Plan, Pre-remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin" [HLA, 1997b]). In general, the area which contains concentrations greater than the DHS provisional action level of 18 μg/L is 5 to 6 miles in length, oriented from northeast to southwest, approximately 1 mile in width, and up to 800 feet in depth. This approximate perchlorate distribution is based on maximum concentrations detected in any sample or at any depth within a given well.

It should be noted that for the majority of these wells, only a single sample has been collected. In addition, there is uncertainty regarding the concentrations above the 18 μg/L provisional action level in both the northernmost and southernmost portions of the plume. Therefore, the known distribution may change as wells are resampled or new wells constructed and sampled.

2.2 Toxicity/Provisional Action Level

A significant source of uncertainty associated with the potential effect that concentrations of perchlorate ion in groundwater may have on the selection of a remedy for the BPOU is the limited data available on the toxicity of low concentrations of perchlorate to humans. Limited animal studies have been performed and no studies documenting human effects at low concentrations are available. Therefore, the provisional Reference Dose (RfD) and provisional action level established by DHS have an inherently high level of uncertainty. These may be subject to significant change once appropriate studies have been conducted.

The primary human health concern related to perchlorate is that it interferes with the thyroid gland's ability to utilize iodine to produce thyroid hormones. While high doses of perchlorate (mg/kg per day levels) have been used therapeutically in medicine, no studies have examined the health effects at the lower dosages potentially received from the ingestion of groundwater at concentrations present in the San Gabriel Basin groundwater. Examples of therapeutic perchlorate use are as a medicine to treat Grave's disease, a condition in which excessive amounts of thyroid hormone are produced, and in Europe to counteract the side effects of the heart drug amiodarone.

In December of 1992, the U.S. EPA National Center for Environmental Assessment (NCEA) responded to a request by U.S. EPA Region IX to evaluate the toxicity of perchlorate in soil and groundwater. Based on limited data on the toxicity of this ion, NCEA recommended a provisional RfD for soil and groundwater that included a conservative safety factor and correlated with acceptable levels of 70 mg/L and 3.5 μg/L, for these media, respectively. NCEA later stated in a letter dated February 25, 1997, that these provisional RfDs were merely opinions provided to EPA regional officials and were not to be considered formal EPA policy.

In April of 1993, the Perchlorate Study Group (PSG) was formed by the U.S. Air Force, various aerospace companies, and the two primary manufacturers of perchlorate compounds. The mission of the PSG was to review and evaluate information on the toxicity of perchlorate and develop better information on what constitutes an acceptable level of perchlorate in soil and groundwater.

In June 1995, the PSG submitted a position paper to the U.S. EPA presenting the groups' findings. The U.S. EPA again reviewed available toxicological data on perchlorate and concluded that although information was available on the effects of high concentrations of perchlorate on the thyroid, there was not enough information on the effects of long-term exposure to low concentrations. In October 1995, the U.S. EPA responded to the PSG paper by recommending a provisional reference dose correlating to an acceptable level in groundwater that ranged between 3.5 and 17.5 μg/L. Because there was limited information available, the U.S. EPA recommendation includes a large margin of safety. In fact a 300-fold margin of safety above the level at which no health effects were observed was used to establish the 17.5 μg/L provisional standard. This value became the 18 μg/L value currently used as the DHS provisional action level.

In March 1997, the PSG assembled a technical Peer Review Panel of nationally recognized scientists to evaluate the health effect of perchlorate in drinking water. The conclusion of this panel was that there are insufficient toxicological data available to establish a technically defensible RfD or support the U.S. EPA provisional RfD.

In May 1997, the Air Force and the PSG brought the Peer Review Panel back together with California state and federal regulators in Cincinnati, Ohio. The purpose was to have the panel develop a protocol and the scope of studies that would lead to a recommendation to U.S. EPA for a new RfD which could serve as the basis for a groundwater MCL. The Air Force and the PSG have undertaken to commence the necessary studies in August 1997, interpret the data, peer-review the results, and submit recommendations to U.S. EPA by July 1998.

It should be noted that to date the U.S. EPA has not endorsed the Peer Review Panel but did have representatives participate on the panel. Further, U.S. EPA has not endorsed the evaluation process or committed to a schedule for review of the resultant recommendations or its effect on the U.S. EPA's former provisional RfD. As a result it is uncertain how long it will take for the provisional RfD to be revised and an MCL established.

In February 1997 the DHS set a provisional action level for perchlorate in groundwater at 4 μg/L, but at that time laboratory methods were not designed or approved to measure concentrations this low. In May of 1997 DHS, based on the results of U.S. EPA's recommendations, revised its provisional action level from 4 μg/L to 18 μg/L. DHS stated that it had reevaluated scientific studies in greater detail and had determined that 18 μg/L is consistent with the range of perchlorate exposures the U.S. EPA considers protective of human health. DHS requires that water suppliers promptly notify customers whenever perchlorate is present in concentrations greater than 18 μg/L.

2.3 Analytical Methodology and Detection Limits

At the time that the U.S. EPA set its provisional RfD and the DHS set its provisional action level for perchlorate in groundwater, no EPA laboratory method existed and few laboratories were set up to analyze for perchlorate. Some laboratories were using a modification of EPA Method 300 (Ion Chromatography), while others were using an Ion Selective Electrode (ISE). Reporting limits for analysis of perchlorate in water were generally in the range of 400 to 1,000 μg/L.

It was not until April 1997, that the DHS (Sanitation and Radiation Laboratories Branch) attained the current reporting limit of 4 μg/L after having performed its own method development. To date, this method has not be peer reviewed. Because perchlorate is not a regulated substance DHS does not issue laboratory certification for method analysis. DHS will however issue informal approval to perform perchlorate analysis once a laboratory meets DHS requirements.

To receive DHS approval the laboratory must hold a current certification for EPA Method 300, develop a Standard Operating Procedure (SOP), determine its Method Detection Limit (MDL), and prepare a data package demonstrating its ability to perform the analysis. The laboratory must then contact the DHS who will send out a field auditor. The laboratory must perform analysis on the samples with acceptable results (±10%) in the presence of the auditor. To date, at least six laboratories in California have received approval.

3.0 PREVIOUS PERCHLORATE TREATABILITY REVIEW

In response to the presence of perchlorate in groundwater at Aerojet's Sacramento facility, a considerable amount of work has been performed to address perchlorate treatability. This work, consisting of technology screening, bench-scale studies, pilot-scale studies, and the design of a full-scale (1,500 gpm) system, was performed by Aerojet and a consultant starting in 1994.

3.1 Literature Review

In 1994, Aerojet completed an initial screening of technologies available for treatment of perchlorate. An on-line data search was first performed. The following databases were searched:

- Energy SciTech (1974-1994)
- Ei Compendex Plus (TM) (1970-1994)
- National Technical Information Service (1964-1994)
- Aerospace Database (1962-1994)
- Chemical Engineering Abstracts (1970-1994)
- Biotechnology Abstracts (1970-1994)
- PTS Aerospace/Defense Markets (1986-1994)
- Pollution Abstracts (1970-1994)
- Analytical Abstracts (1980-1994)

Only limited information on the treatment of water for perchlorate was found, and the available data addressed the treatment of high concentration wastewaters, not low concentrations in groundwater. The technologies for which information was found include both biological and physical/chemical treatment methods.

Biological Methods

Biochemical reduction of oxygen-containing compounds, like perchlorate, with the simultaneous biochemical oxidation of organic matter contained in sludge from municipal wastewater treatment plants was the subject of three patents with dates from 1973 to 1994. The patents varied in bioreactor configuration and the source and type of the microorganisms used. Concentrations in wastewater in excess of 7,000 mg/L were the subject of treatment.

A 1973 patent (Yakevlev et al., 1973) describes biochemical oxidation of activated sludge in an unaerated tank. A 1976 patent (Korenkov et al., 1976) is a modification of this approach but a specific microorganism is identified. The source of the microorganism is settled municipal sewage. A 1994 patent (Attaway et al., 1994) held by the U.S. Air Force uses an anaerobic bioreactor and a specific microorganism. Brewer's yeast, cottonseed protein, and whey powder were all added to the bioreactor.

Physical/Chemical Methods

The physical/chemical processes which were reviewed by Aerojet in 1994 included ion exchange, reverse osmosis, an electrochemical process which reduces inorganic oxyhalides, and a process where perchlorate wastewater was treated with an oxidant in supercritical (high temperature, high pressure) water.

The electrochemical method, patented in 1992 (Kaczur et al., 1992), uses an anode and cathode separated by a cation exchange membrane. A 1993 paper (Harradine et al., 1993) describes treatment of perchlorate in wastewater with an oxidant (O_2, air, H_2O_2) under conditions of high pressure (200 atm) and temperature (370°C).

In addition to these two techniques, Aerojet's staff reviewed the applicability of ion exchange and reverse osmosis treatment technologies. Although both ion exchange and reverse osmosis are considered technically proven methods for reducing concentrations of dissolved solids in waters, there are significant technical challenges presented by both methods for treatment of water containing perchlorate.

With respect to ion exchange, common groundwater ions will interfere with perchlorate adsorption. The ion exchange resin is regenerated with brine (usually sodium chloride). Perchlorate concentrations in regeneration brine present a unique disposal or treatment problem.

There are significant operational difficulties associated with the use of reverse osmosis. Like ion exchange, perchlorate is not treated but merely conveyed to a waste concentrate that would be a waste disposal challenge. The resultant brine would contain perchlorate and would be significant in volume. In addition, pretreatment of influent, use of anti-fouling chemicals, and membrane cleaning are time-consuming and costly.

Based on the literature review described above, Aerojet decided to pursue laboratory-scale testing of chemical reduction and biochemical methods.

The BPOUSC is in the process of completing an updated technology screening, building upon past work performed by Aerojet. This effort will include a literature review, a review of recent patents and technical articles, and a review of additional technical performance data which may have been generated by various parties interested in perchlorate treatability but not present in the literature.

3.2 Bench-Scale Laboratory Testing

Bench-scale treatability studies for several biochemical and chemical reduction treatment methods were performed by an Aerojet consultant in 1995. The tested water came from Aerojet's Sacramento facility and contained between 7,000 and 8,000 $\mu g/L$ perchlorate.

Relatively high dosages of several reducing agents (sodium sulfite, sodium bisulfite, and sodium thiosulfate) up to 1,000 mg/L were added under ambient conditions to water containing 7,000 $\mu g/L$ perchlorate. As perchlorate concentrations did not significantly decrease over time, these reducing agents were concluded to be ineffective, and the process was not taken to pilot-scale.

In addition to chemical reduction, Aerojet staff evaluated the use of ion exchange technology in more detail. Time was devoted to resin selection, resin regeneration, and treatment of regeneration wastes. Efforts were also made to develop a method for biodegradation of perchlorate in these wastes.

Two biochemical reduction methods were tested on a bench-scale: a fixed film bioreactor using submerged plastic media, and a fluidized bed bioreactor using a granular activated carbon media (GAC/FB). For both processes the water to be treated was amended with an organic carbon source (acetate or alcohol) and nutrients (nitrogen and phosphorus) before entering the bioreactor.

Both biochemical reduction methods were shown to be effective in reducing perchlorate concentrations. The GAC/FB system was more resilient, recovering more quickly from system upsets such as feed water variations. The GAC/FB system also accommodated a higher (6-fold) perchlorate loading rate of 0.70 grams perchlorate/liter/day in comparison to the submerged plastic media loading rate of 0.11 grams perchlorate/liter/day. Effluents for both processes were below the 400 $\mu g/L$ reporting limit for perchlorate.

Because of the success with the biochemical treatment methods, and due to the comparatively better performance of the GAC/FB method, this method was taken to pilot-scale.

3.3 Pilot-Scale Testing

In 1996, a 30 gpm skid-mounted pilot system, was set up at the Aerojet facility in Sacramento. The pilot-scale system operated between April and December of 1996. Operation of this pilot-scale system allowed optimization of feed rates for the organic carbon source (alcohol) and nutrients (nitrogen in the form of urea and phosphorus in the form of ammonium phosphate). Alcohol was added in molar ratio to perchlorate of approximately 4:1. Nitrogen and phosphorus levels were augmented to be similar to those described in the literature to assure microbial growth.

Effluent concentrations were consistently less than the 400 $\mu g/L$ laboratory reporting limit for perchlorate. Effluent concentrations were 500 $\mu g/L$ for phosphorus, 340 $\mu g/L$ for ammonia-nitrogen, and less than 50 $\mu g/L$ for nitrate-nitrogen.

The initial pilot-scale effluent contained very low or non-detectable levels of bacteria. After one month of operation, bacteria were at non-detectable levels.

3.4 Full-Scale Design

Aerojet is in the process of designing a full-scale perchlorate treatment system for one of the groundwater extraction and treatment systems at their Sacramento facility. The design and construction are currently scheduled to be complete in the fall of 1998. The hydraulic loading rate for the system is 1,500 gpm. The full-scale system will be similar to that pilot-tested in 1996.

Aerojet is working with the design contractor to optimize certain design features which will result in lower effluent concentrations. The pilot-scale study was completed prior to the recent reduction in laboratory reporting limits by agency and commercial laboratories and, therefore, Aerojet and its contractor are hoping to modify either the design or operating parameters to produce effluent below the 18 μg/L provisional action level.

In addition, Aerojet and its contractor have located an alternative source of microorganisms. Waste sludge from the food processing industry was determined to contain acceptable microorganisms.

3.5 Biological Treatment Technology Overview

Biological treatment, or biochemical reduction of perchlorate, involves a microbially induced reaction in which perchlorate is biochemically reduced to form chloride, oxygen, and biomass, simultaneous with the biochemical oxidation of an organic substrate. The substrate is typically selected based on its readily biodegradable chemical structure, non-hazardous nature from an environmental standpoint, relatively low cost, and availability.

Biological treatment technologies generally fall into two classes: suspended-growth and attached-growth (fixed-film). Attached-growth systems are expected to be better suited to the relatively low influent perchlorate concentrations and are therefore the focus of BPOUSC efforts. Attached-growth systems can typically attain higher concentrations of microorganisms per unit reactor volume, and because the microorganisms are attached to media within the biological reactor, there is no requirement for return of microorganisms to the treatment reactor.

The GAC/FB technology is an attached growth (fixed film) process which utilizes granular activated carbon as a support medium for biological attachment and growth in a fluidized bed reactor. The GAC/FB technology offers the additional advantage of greater surface area on which microorganisms can attach and grow, as well as the presence of activated carbon, which provides some buffer capacity to varying operating conditions. Groundwater, amended with an organic substrate (e.g., alcohol, acetate) and nutrients (nitrogen and phosphorus), is introduced into the treatment bed. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, simultaneously bioreducing the perchlorate. Thus, the microorganisms multiply to a steady-state level, determined by the organic loading to the system.

Non-viable microorganisms eventually become detached from the media, and exit the system in the groundwater effluent, allowing new microorganisms to attach and reproduce. The reaction takes place under anoxic conditions, and therefore no air or oxygen (other than that contained in the influent water) is introduced to the system.

4.0 DATA REQUIREMENTS

The long-term goals of this treatability work are: 1) to demonstrate the technology can achieve effluent goals for perchlorate and nitrate concentrations, and 2) to collect the data necessary for the design and construction of a full-scale treatment unit that will be part of the BPOU treatment train, delivering potable water to local and regional water purveyors.

The objectives of this Phase 1 treatability study are to evaluate the performance of the GAC/FB treatment technology previously tested at Aerojet's Sacramento facility with the following modifications:

- Decrease the concentration of perchlorate in the influent to a concentration representative of that which will be present in San Gabriel Basin groundwater

- Increase the concentration of nitrate in the influent water to a concentration representative of San Gabriel Basin groundwater

- Achieve a lower perchlorate concentration in treatment plant effluent

- Test the effectiveness of an alternative source of microorganisms.

- Evaluate the characteristics of the effluent to ensure potability.

Phase 1 testing is planned at Aerojet's Sacramento facility because many of the pilot system components are onsite, staff familiar with prior pilot system construction and operation are available, and there are no complicating issues related to the discharge of treated water.

4.1 Demonstrate Technology Can Achieve 18 µg/L Limit or Lower

At the time the pilot-scale study was performed at Aerojet's Sacramento facility, the goal was to produce effluent that was less than the 400 μg/L laboratory reporting limit current at that time. When the pilot-scale study was completed, the effluent generally was characterized by perchlorate concentrations less than 100 μg/L. Measurement of concentrations at this level had a higher level of uncertainty as they were below the established reporting limit. At that time it was not possible to measure to the current reporting limit of 4 μg/L. Therefore, it was not possible to optimize system flow rate, organic carbon source, or nutrients to see if lower effluent concentrations were possible. Therefore, it is uncertain if the full-scale system to be constructed by Aerojet in Sacramento may reach treatment goals for the BPOU. Treatability studies will need to demonstrate that a sufficiently low perchlorate concentration in treatment plant effluent is possible.

4.2 Evaluate Lower Perchlorate Influent Concentration

Based on the distribution of perchlorate in San Gabriel Basin groundwater, the configuration of extraction wells and flow rates described in the December 1996 Pre-Remedial Design Report (CDM, 1996), and modifications to the extraction plan discussed with U.S. EPA, the BPOU extraction system, as conceived, would produce groundwater containing concentrations of perchlorate between 50 and 100 μg/L. This value was estimated by selecting surrogate wells for each extraction well location, assigning recently measured concentrations from each surrogate well to its corresponding extraction well, and flow-weighting these concentrations based on expected pumping rates to produce a flow-weighted average concentration for the BPOU extraction system. This method is a rough estimation of concentrations that will be initially extracted. The actual concentrations present in the extracted groundwater will be known after extraction wells are constructed and pumped at their designed flow rate.

Although concentrations of perchlorate in groundwater at Aerojet's Sacramento facility that were used as influent to the pilot test ranged from 7,000 to 8,000 mg/L, there are wells at the Sacramento facility that have lower perchlorate concentrations. This treatability test will extract water from a well containing a perchlorate concentration representative of that anticipated in San Gabriel Basin. The selected well (40-11) is currently part of one of Aerojet's groundwater extraction and treatment systems (GET-B). This well consistently produces water containing approximately 50 ug/L perchlorate and 50 to 70 mg/L nitrate.

4.3 Utilize Higher Nitrate Influent Concentration

Pilot testing at Aerojet's Sacramento facility treated groundwater characterized by low (1.5 mg/L) nitrate concentrations. The results of the pilot-scale study performed in Sacramento show effluent nitrate concentrations less than 0.05 mg/L. This suggests that along with consumption of alcohol and reduction of perchlorate, that reduction of nitrate is also occurring in the fixed film bioreactor.

Supporting evidence that the same anoxic conditions that contribute to the reduction of perchlorate may also reduce nitrate concentrations may be found in the literature where processes using bacterial denitrification of wastewater have been described. Although denitrification has not been widely applied to drinking water systems, such systems do exist in Colorado, Texas, and France. One such system was designed for the town of Wiggins, Colorado to denitrify their drinking water. The process equipment, designed and testing performed by Joann Silverstein of the University of Colorado, Boulder (Silverstein, 1997). The system consists of a packed tower fixed film bioreactor where denitrifying bacteria are supported on a high-porosity plastic media.

This observation could have a significant beneficial effect on the BPOU project as influent nitrate concentrations have been estimated between 20 and 25 mg/L, by the same method described above to estimate influent perchlorate concentrations. Although these concentrations are well below the 45 mg/L MCL, they are substantially higher than concentrations currently received by customers of MWD and TVMWD. Should the GAC/FB biochemical system prove to be an effective method of reducing nitrate concentrations in treatment plant effluent, it may be possible to reduce both perchlorate and nitrate concentrations.

Preliminary evaluation of candidate wells identified a well (40-11) at Aerojet's Sacramento facility that has historically produced water containing between 50 and 70 mg/L nitrate. In addition, this well is part of a current groundwater extraction system (GET-B) so that water quality is anticipated to remain relatively constant for the duration of the pilot test.

4.4 Evaluate Different Source of Microorganisms

The source of microorganisms in the previous study was municipal wastewater treatment plant sludge. This approach presents a concern related to the introduction of pathogens into potable water supply. Pilot-scale work performed at Aerojet's Sacramento facility demonstrated that pathogens are not present in pilot plant effluent; however, the potential presence of these pathogens remains a concern.

The Phase 1 treatability study will utilize waste sludge from the food processing industry. The waste sludge will likely contain microorganisms appropriate for perchlorate reduction, but lack the pathogens that may be of concern.

4.5 Potability of Treated Water

For the BPOU project to be viable it must deliver potable water to local and regional water purveyors. Therefore the selected treatment train must produce water that meets all federal and state requirements for a potable water supply. Embodied in the objectives described above are the need to produce water that contains acceptable concentrations of perchlorate and nitrate and lacks pathogens. In addition this pilot-scale testing will evaluate all other applicable water quality parameters to ensure treatment plant effluent can achieve other potable water quality goals.

The source water and the effluent will be tested for an appropriate range of water quality parameters including those specified in the Safe Drinking Water Act and the California Code of Regulations, Title 22.

4.6 Phase 2 Pilot-Scale Treatability Study

Assuming Phase 1 results demonstrate effluent goals can be met, Phase 2 testing would be performed. It is the intention of the BPOUSC to perform Phase 2 treatability testing at a site in the San Gabriel Basin. Details and logistics regarding this testing will be developed during the performance of Phase 1 testing. Details which will be resolved during Phase 1 testing will include the well site where treatability testing will be performed, the flow rate at which the testing will be performed, and the method and condition under which the effluent will be delivered.

Phase 2 testing could commence in early 1998, with testing complete and a draft report available for EPA review later in 1998. Adherance to this schedule is dependent upon several key assumptions. These include identification of a suitable site for testing, an agreement with the current well owner/operator, resolution regarding the flow rate to be tested, resolution regarding use of the water and disposal of wastewaters, and the ability to design and construct a Phase 2 system at the selected flow rate within this timeframe.

In late 1998 Aerojet's Sacramento perchlorate treatment unit should be on-line and several months of performance data should be available. Input from both phases of treatability testing and performance data from Aerojet's Sacramento treatment unit would allow the BPOUSC to proceed with design of the BPOU project.

Preliminary Phase 2 treatability testing objectives are to: 1) determine the efficiency of perchlorate reduction, 2) evaluate required nutrients, 3) assess factors affecting biomass stability, 4) assess the effect of various nitrate concentrations, 5) evaluate relative bacterial preference for perchlorate and nitrate and the role that competing electron acceptors play in system performance and 6) establish filtration/ disinfection requirements for potable water use.

5.0 TREATMENT EQUIPMENT DESCRIPTION

The Phase 1 treatment system includes an extraction well, an air stripper with vapor phase carbon air emission control, a bioreactor with granular activated carbon, a fluidization pump, a nutrient feed system, an alcohol feed system, a biological growth control system, a 500 gallon equalization tank, and assorted pumps, valves, sensors, and piping.

The extraction well (40-11) is currently connected to the GET-B treatment system. This connection will remain, but a valve will be inserted in the line to allow flow to be diverted from the GET-B system to the Phase 1 treatment system as needed. This will allow well 40-11 to continue operating at a constant flow rate as the Phase 1 system is operated in recycle mode and as the treatment system flow rate is increased to the maximum design rate for this treatability test.

The conceptual design of the BPOU project central treatment plant includes air stripping technology to remove VOCs from San Gabriel Basin groundwater. For purposes of this Phase 1 treatability test it has been assumed that perchlorate removal will occur following VOC removal. Therefore for Phase 1 treatability testing VOCs will first be removed with the use of a portable air stripper. This portable air stripper contains a 70 gallon reservoir in its base which with appropriate sensors will be operated to ensure constant flow to the bioreactor. VOC-free groundwater will then flow into the GAC/FB bioreactor.

Following completion of planned Phase 1 treatability testing consideration will be given to reversing the order of the air stripper and bioreactor. This configuration was not initially selected for testing as the biological treatment of VOCs in groundwater may result in the formation of vinyl chloride, a compound not effectively removed by vapor phase carbon, or the presence of recalcitrant VOCs in the treatment stream which may complicate the interpretation of the effectiveness of perchlorate and nitrate treatment.

An alcohol metering line, constructed of stainless steel tubing, will be connected to the bioreactor influent line. The alcohol will be added to the influent to provide a readily-degradable carbon source for the microorganisms. The alcohol will be purchased in 55-gallon drums. Because the alcohol is flammable, the drums will be stored in a fire-rated outdoor storage cabinet which contains an integral sump for spill control. The alcohol will be metered from the 55-gallon drum using a hazardous duty diaphragm metering pump which is UL-listed for use in Class I, Group D, Division I hazardous locations. Containment around the metering pump will be provided for spill control. The flow rate of the alcohol will be measured with a graduated cylinder and stopwatch.

The central reactor for the GAC/FB pilot system will be leased from a contractor. The bioreactor is 20 inches in diameter and 15 feet high. Additional components for the pilot system are available at Aerojet's Sacramento facility. The pilot system, rated for a once through flow rate of 30 gpm (113.6 liters/minute), is skid mounted.

A photograph of a generalized GAC/FB bioreactor is presented as Figure 5-1. A generalized process and instrumentation diagram (P&ID) is presented as Figure 5-2. These figures are not specific to this Phase 1 Pilot-scale test. The specific components and configuration of the treatability testing equipment to be used for Phase 1 treatability testing will differ from these figures to suit treatability test objectives.

The GAC/FB pilot unit is enclosed in a weather resistant container for protection from freezing during cold weather operation. The piping located outside of the reactor column will be insulated as appropriate. The purpose is to maintain a relatively constant water temperature in the GAC/FB reactor and prevent icing if the ambient temperature drops significantly. Previous pilot-scale testing was performed from April through December of 1996 and only minor changes (1 to 2 degrees) in temperature were observed.

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line

2. Air stripper effluent line

3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line

4. 25 percent of flow path in GAC/FB bioreactor

5. 50 percent of flow path in GAC/FB bioreactor

6. 75 percent of flow path in GAC/FB bioreactor

7. Effluent line from GAC/FB bioreactor

Samples will be collected from the 25 %, 50 %, and 75 % positions along the bioreactor flow path using individual 1/2 inch PVC tubing with screened ends which extend from the top of the bioreactor down to the appropriate horizon in the bioreactor. All three tubes will be connected through a common manifold with a three-way valve for ease of sample collection.

After the effluent exits the bioreactor, it will flow by gravity to a 500-gallon, polyethylene equalization tank equipped with level controls. From the equalization tank, the effluent will be discharged directly to the GET-B treatment system. The purpose of this equalization tank is to assure the pump moving water to the GET-B system receives a constant flow.

The equalization tank pump will be a centrifugal end-suction pump. Operation of the effluent equalization tank pump will be controlled by high-high, high, and low-level switches in the equalization tank. When the high-high level switch is activated a signal will be sent to the solenoid valve to close the influent line. The closed valve will eliminate flow to the bioreactor which will then operate in recycle mode to prevent spills. In addition, the high-high level switch will act as a fail-safe shutdown and signal the alcohol metering pump to turn off so that it no longer supplies alcohol to the influent line. When the high-level switch activates, the equalization tank centrifugal pump will be sent a signal to turn on, discharging the contents of the tank to the GET-B Treatment Pond. When the low-level switch activates, the equalization tank pump will be signaled to turn off. A totalizer will be installed to measure the total water flow treated by the system.

Filtration of the treatment system effluent will not be necessary before discharge. Pilot-scale testing of filtration equipment may be necessary prior to full-scale system design, but this testing if needed will be performed as part of the Phase 2 Treatability Study.

6.0 PILOT SYSTEM OPERATION AND MAINTENANCE PLAN

6.1 System Start Up and Operation

Upon delivery of the GAC/FB bioreactor to the site, a general/mechanical contractor will perform the mechanical and electrical installation. During system construction, personnel from HLA and Aerojet will provide oversight. The system will be filled with water and hydraulically operated prior to adding carbon or microbial seed to the bioreactor to ensure proper, leak-free operation.

After leak and mechanical testing, the system will be drained and the GAC/FB reactor column will be filled with the recommended amount of granular activated carbon. The remaining free volume of the bioreactor will then be filled with process water and the microbial seed.

From this point forward system operation is separated into two periods. The first is the startup period where microorganism growth and attachment occurs and basic bioreactor operating conditions are established. The startup period is planned for 2 weeks. The second period is referred to as the performance monitoring period where system operating conditions are optimized and performance monitoring samples collected. The performance monitoring period is expected to last 6 weeks.

During the startup period the bioreactor will be operated in recycle mode for approximately one week to allow for growth and attachment of the microorganisms to the GAC. During recycle mode, groundwater will not be flowing through the system. Batch additions of alcohol, nutrients, and perchlorate will be added on a regular basis to support the microbial growth. As an option the bioreactor may be started up in flow through mode.

After sufficient time is allowed for microorganism attachment (one week), groundwater containing perchlorate and nitrate will be introduced to the bioreactor. At this time, the alcohol and nutrient feed systems will be started. The flow of groundwater will be gradually increased to the design rate for the treatability test. Initial flow will be 5 to 10 gpm, but as measured parameters show the bioreactor has stabilized the flow rate will be incrementally increased to the 20 to 30 gpm range.

The flow rate and the dosage of alcohol will be adjusted during the startup period to establish a stable microbial population in the bioreactor. Nutrients will be dosed at a rate sufficient to satisfy microbial requirements.

To assist in establishing stable operating conditions during the second portion of the startup period a profile of reactor conditions will be obtained. Water samples will be collected from sample ports on the influent and effluent lines and at the 25, 50, and 75 percent points along the bioreactor flow path. The profile of selected parameters and concentrations of selected ions including perchlorate will be evaluated to examine perchlorate destruction. These data will also be used to vary the alcohol and hydraulic loading rates in a controlled, step-like manner until the target organic loading rate is established.

Targeted analytical parameters will be measured before and after each change in operating conditions. Although it is anticipated that the system will respond rapidly to changes in influent quality, nutrient feed, or alcohol feed, approximately 24 hours will be allowed to pass, samples collected and results interpreted before additional changes are made. Assuming one day turn-around for laboratory analysis this will mean that operating changes will be made no more frequently than every 48 hours. This will ensure reactor stabilization and allow a better understanding of how changes to reactor operation affect effluent quality. Should results from the initial startup period and measurement of field parameters suggest the reactor stabilized more rapidly, this protocol will be modified.

Once the microbial populations have been established and stable bioreactor operating conditions achieved (2 week startup period), the system will be operated in the performance monitoring mode (6 weeks). System operating conditions will be optimized to match the feed rate for alcohol with perchlorate and nitrate destruction. The goal is to maximize perchlorate and nitrate destruction and produce effluent free of detectable alcohol. Sample collection and analysis will be performed as described in Section 7.0.

Analytical reporting limits are below health based standards for potable water so production of effluent without detectable alcohol will satisfy water supply requirements.

HLA personnel will assume operation and maintenance responsibilities. Operation and maintenance activities and frequencies will be modified as necessary to ensure proper control and performance of the Phase 1 treatment system. A logbook will be maintained at the site for recording all operating activities and observations. The logbook will serve as a daily checklist to ensure that necessary maintenance, sampling, and observations are conducted.

6.2 Health and Safety Plan

A Site Health and Safety Plan, prepared by HLA, will govern the activities of all HLA workers at the site who are associated with this pilot-scale treatability study. This plan will be prepared after Work Plan approval but prior to system start up.

7.0 SAMPLING AND ANALYSIS PLAN

The sampling and analysis portion of the Phase 1 treatability study is divided into two phases: a system startup period and a performance monitoring period. - During the first week of the startup period the objective is to build and establish the necessary population of microorganisms. The monitoring of field parameters and sampling and analysis schedule for this period is designed to support this objective. Field parameters will be measured and reported at least once each day. Although water quality samples will be collected on a daily basis these samples will be analyzed for the limited number of laboratory analytes necessary to ensure the microorganisms are receiving sufficient organic substrate and nutrients.

In addition, early in the first week one influent sample will be collected and analyzed to provide a complete characterization of the source water. This will allow for modification of the analytical schedule if appropriate. Samples of air stripper influent and effluent will be collected and analyzed for VOCs as the air stripper is brought on-line to ensure VOCs are removed from the influent to the bioreactor.

During the second week of the startup period, monitoring of field parameters and sampling will be sufficiently frequent to provide complete characterization of the process influent and effluent, collect data to allow for bioreactor profiling, and allow adjustments to operating conditions.

After steady-state operating conditions are reached, less frequent but regular performance monitoring will be conducted to monitor treatment process performance.

7.1 Field Data Collection

During the first week of system startup, frequent monitoring of field parameters will be performed to assure steady-state conditions while microorganism populations are increasing and stabilizing. The parameters to be measured in the field include flow rate, dissolved oxygen (DO), pH, oxidation-reduction potential (redox potential), and temperature.

Flow rates will be continuously monitored with in-line, correlated flow meters. Flow meter readings will be confirmed by monitoring the effluent volume that accumulates in the polyethylene tank. A reference line for tank volume versus fluid height is present on the outside of the tank. The flow from the alcohol metering pump will be measured using a graduated cylinder and a stopwatch.

The bioreactor influent and effluent DO will be monitored at least once each day with a field DO meter and field probe or equivalent in-line device. Each day the DO meter will be calibrated using the air calibration method. DO measurements will be corrected for temperature and pressure.

A hand held pH meter or equivalent device will used to measure and record pH at least once each day. The meter will be standardized to two reference buffer solutions prior to obtaining each pH measurements.

A hand held platinum electrode or equivalent device will used to measure and record redox potential at least once each day.

The temperature of bioreactor influent and effluent will be measured at least once each day with a hand held mercury thermometer or equivalent device.

During the second half of the startup period and the performance monitoring period field parameters will be measured and recorded on at least a daily basis. Field parameters will be measured and recorded whenever a water quality sample is collected.

7.2 Sample Collection

Seven sample ports will provide for the collection of water quality samples and measurement of field parameters at key locations throughout the treatment system. These seven sample ports will be located as follows:

1. Air stripper inlet line
2. Air stripper effluent line
3. GAC/FB influent line after strainer, alcohol feed, nutrient feed, and recycle line
4. 25 percent of flow path in GAC/FB bioreactor
5. 50 percent of flow path in GAC/FB bioreactor
6. 75 percent of flow path in GAC/FB bioreactor
7. Effluent line from GAC/FB bioreactor

The sampling and analytical schedules for the startup period are presented in Tables 7-1 (week

1) and 7.2 (week 2). The sampling and analytical schedule for the performance monitoring period can be found as Table 7-3. These tables illustrate the location and frequency of sample collection as well as the compounds, ions, and parameters to be monitored.

Sample tubing will be connected to the GAC/FB bioreactor influent and effluent lines using labcock ball valves to reduce the velocity of the sample as it enters the sample bottles and thereby reduce turbulence. Tubing and valves on sample port lines will be opened and extensively flushed prior to sample collection to ensure collection of representative samples.

Samples collected from the pilot treatment system will be in the form of discrete grab samples. Grab samples provide better control than composite samples for monitoring the effects that changes in influent quality and reactor operating conditions have on reactor performance.

After collection, VOC samples in zero-headspace vials will be inverted and inspected for the presence of bubbles. All samples will be placed into coolers for same-day transportation to the analytical laboratory. Influent and effluent samples will be stored and transported on ice to preserve the samples and to prevent cross contamination of samples. Upon arrival at the laboratory, the samples will be stored at 4°C in walk-in coolers. Samples collected on Sunday or holidays will be stored in a refrigerator onsite, as the laboratory is not open that day. Samples will be delivered to the laboratory as soon as possible.

Sample container selection and sample preservation techniques will comply with U.S. EPA guidelines detailed in SW-846. Sample tags indicating sample location, date and time of sampling, and the initials of the individual who collected the sample will be attached to each sample. Each sample will be logged onto a chain-of-custody form. Copies of all chain-of-custody forms generated during the pilot study will be kept on file and available for review.

7.3 Analytical Testing

The project laboratory will perform analyses for volatile organic compounds (VOCs), ammonia-nitrogen, alkalinity, chloride, phosphate, BOD, COD, total suspended solids, total dissolved solids, turbidity, perchlorate, chlorate, chlorite, hypochlorite, chloride, ammonia, nitrate, nitrite, sulfate, sulfide, alcohols, metals, and bacteriology. The purpose of this testing is to evaluate the effectiveness and mechanisms of perchlorate reduction. Analytical testing will be conducted using the U.S. EPA approved methods. Analytical method requirements are detailed in Table 7-4. Detection limits for all parameters are below health based water quality (drinking water) standards where such standards exist.

7.4 Quality Assurance Project Plan

HLA's Quality Assurance Management Plan (QAMP) assures that appropriate measures will be taken to assure project data quality objectives (DQOs) are achieved and data integrity is maintained. In addition to DQOs, HLA's QAMP addresses methods for sample collection and handling, sample custody, the type and frequency of quality control samples, laboratory quality control procedures, methods for data verification, reduction, management and interpretation, record keeping and corrective actions.

For field activities approximately five percent of all samples will be collected as splits (duplicates). Sample splits (duplicates) and blanks will be submitted to the project laboratory on a more frequent basis during the startup period when samples are collected more frequently. Trip blanks will be used where laboratory contamination is a concern. Field blanks will be used where field contamination is a concern. Quality control samples will be collected, but less frequently during the performance monitoring period. Sample splits (duplicates) will submitted more frequently for analyses that are performed more frequently. Table 7-5 describes the type and frequency of field quality control samples. All samples will be appropriately labeled, packaged, and will be shipped to the project laboratory under chain of custody.

Analysis of samples by the project laboratory will be performed in conformance with laboratory QC procedures and QC procedures specified by each of the certified or approved analytical methods. Table 7-6 details laboratory quality control procedures and statistical analysis guidelines.

8.0 WASTE STREAM MANAGEMENT

Under approval of the Central Valley Regional Water Quality Control Board, system effluent will be discharged directly to the GET-B treatment system. At the conclusion of the study, TCLP testing will be conducted to verify the GAC does not exhibit the hazardous characteristics. After reviewing test results, the GAC will be disposed of in accordance with applicable laws and regulations.

9.0 IMPLEMENTATION TEAM AND COMMUNICATION PLAN

9.1 Implementation Team

Activities described here will be implemented by the team shown on Figure 9-1. Individuals responsible for the implementation of the activities in this Work Plan are: 1) appropriately qualified and licensed, 2) have considerable knowledge of a range of treatment technologies and experience designing and performing bench-scale and pilot-scale treatability tests, and 3) are experienced with the methods and procedures including those related to Health and Safety and Quality Assurance required to perform the proposed work.

This treatability study will be performed by a team of personnel from HLA and Aerojet under the direction of BPOUSC Co-chairpersons, Don Vanderkar and Steve Richtel.

9.2 Communication Plan

Communication during the implementation of this treatability work will be conducted in a manner to facilitate timely decision making and communication of work progress. Lines of communication are shown on Figure 9-1.

John Catts will serve as technical director for the work and be responsible for communicating work progress to the BPOUSC and U.S. EPA.

It is anticipated that work progress and results will be communicated via telephone conversations, meetings, written correspondence, and reports as described in Section 10.0.

10.0 SCHEDULE

This Work Plan was prepared within the schedule proposed by the BPOUSC in the document entitled "The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin" dated July 15, 1997 (HLA, 1997a) This Work Plan was first issued in draft form on August 26, 1997. The U.S. EPA issued comments and approved the Work Plan in a letter dated September 12, 1997. The BPOUSC issued a "Final Phase 1 Treatability Study Work Plan" on October 6, 1997. The U.S. EPA issued comments on this document in a letter dated October 16, 1997.

This "Revised Final Phase 1 Treatability Study Work Plan" incorporates changes and additions resulting from design and construction of the Phase 1 treatment system and also addresses U.S. EPA comments from both September 12, 1997 and October 16, 1997 letters.

Planning and preparation for Phase 1 treatability testing commenced in mid September 1997. Assembly of the pilot-scale bioreactor is presently in progress.

The BPOUSC will provide U.S. EPA with progress reports in the form of conference calls approximately 30 and 60 days following approval of this Work Plan. Assuming an U.S. EPA Work Plan approval date of September 12, 1997, teleconference progress reports will be held in mid-October and mid-November, 1997.

The BPOU will submit to U.S. EPA a written Phase 1 treatability testing progress report within 75 days of Work Plan approval. This progress report will contain preliminary Phase 1 results if available. In addition this progress report will contain either a Supplemental Work Plan for Phase 2 Treatability Testing or an explanation as to why additional Phase 1 testing is necessary before a Phase 2 Work Plan can be prepared, and a planned submittal date for a Phase 2 Work Plan. These recommendations may include additional testing with reversal of the air stripper and bioreactor if appropriate.

Regardless, this written progress report will serve as the basis for establishing the schedule for the balance of Phase 1 treatability testing. A schedule for Phase 1 treatability testing is provided below with tentative completion dates for activities that will occur following the submittal of the written progress report on November 27, 1997.

Task Description	Duration from approval	Task Completion Date
Draft Phase 1 Work Plan	---	8/26/97
EPA, DHS, MWD Review	0 days	9/12/97
Progress Report (telephone)	30 days	10/12/97
Phase 1 Mobilization	45 days	10/27/97
Progress Report (telephone)	60 days	11/12/97
Written Progress Report	75 days	11/27/97
Phase 1 Testing	105 days	12/27/97
Draft Phase 1 Report	150 days	2/25/98
EPA, DHS, MWD Review	165 days	3/12/98
Final Phase 1 Report	180 days	3/25/98

11.0 REFERENCES

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APPENDIX B

DEVIATIONS FROM FINAL PHASE I TREATABILITY STUDY WORK PLAN

DRAFT

DEVIATIONS FROM FINAL PHASE I TREATABILITY STUDY WORK PLAN

The following deviations/additions to the Phase I Work Plan relate to equipment used during the study:

- An overflow arrangement was set up for the air stripper reservoir to ensure that the reservoir level stayed constant and therefore a constant flow rate could be provided to the bioreactor downstream. The influent flow rate to the air stripper was purposely set approximately 2 gpm higher than the effluent discharge from the reservoir. The water overflow drained out of the reservoir into a nearby overflow tank. When this overflow tank was full, the water was pumped back to the GET-B treatment system pond.

- The flow rate of ethanol was measured by monitoring changes in the ethanol supply drum level. This method proved to be more accurate than using a graduated pipet connected directly to the pump discharge.

- The GAC/FB bioreactor was provided as a turnkey unit and was modified to meet the needs of the study. Several of the components provided with the bioreactor were not used during the study. These components were shown in the work plan (Figures 5-1 and 5-2). The equalization tank shown in the drawing is not used, rather the air stripper reservoir serves the same purpose. The oxygen generation system, bubble contactor, and educator will not be used during this study. However, the compressor, which is part of the oxygen generation system, is used to supply air to air-operated valves within the unit as well as the carbon separator and return system.

- The biological growth control system at the top of the reactor was automatically controlled by a timer.

- A carbon capture and return system was installed in the reactor effluent pipe.

- The sample ports were labeled in the following manner. A sample port (BS-C) was added to the undiluted groundwater supply line after ethanol injection. Sample collection from BS-C was incorporated into the work plan Week 1, 2, and 3 sampling and analysis plans.

  1. Air stripper inlet line (Port A)
  2. Air stripper effluent line (Port B)
  3. Air stripper effluent line, post-ethanol injection, pre-mix with recirculation water (Port BS-C)
  4. GAC/FB diluted reactor inlet influent line (Port C)
  5. 25 percent of flow path in GAC/FB bioreactor (Port D)
  6. 50 percent of flow path in GAC/FB bioreactor (Port E)
  7. 75 percent of flow path in GAC/FB bioreactor (Port F)
  8. Effluent line from GAC/FB bioreactor (Port G)

The following deviations/additions to the Phase I Work Plan relate to treatability study operations:

periodically, with splits taken according to the types of analyses being conducted at the time. Blanks were taken periodically when volatile analyses were going to be performed.

- Profiles of DO concentration within the bioreactor were collected by lowering a DO probe directly into the bioreactor and observing DO at different heights along the reactor column.

- Field parameters and water samples could not always be collected every day. Unforeseen events such as storms, power outages, and equipment problems interfered on a few occasions with data collection and sampling. In addition, parameters or samples were not collected on some weekends or major holidays.

- During the startup period the bioreactor was operated with 100 percent recirculated water for only 2 days, rather than 1 week as described in the work plan. It was decided that flow-through operation would provide the best consistent environment to foster microorganism growth and attachment to the GAC. However, the groundwater well flow rate was increased slowly during startup because there was a concern that if the groundwater well flow rate was increased too quickly, most the biomass might wash out of the system before it was completely attached to the GAC.

- The actual operational plan changed from that listed in the work plan. In the work plan there were two distinct operational periods. The startup period was to last approximately 2 weeks and then the performance monitoring period was to last 6 weeks. It was thought that complete perchlorate and nitrate destruction would be obtained by the startup period. Actual operations are divided into two different periods: operations with high influent DO (4 to 8 mg/L) and operations with low influent DO (0.5 to 1 mg/L). The influent DO concentration was determined by whether or not the air stripper on the bioreactor influent was online or offline. During each period, profile samples were collected, but a true performance monitoring phase was conducted only during low influent DO operations. Complete perchlorate and nitrate destruction was obtained at the highest flow rates. Eighteen weeks were required to achieve the goals of the study.

- In general, a modified Week 1 sampling and analysis plan was used while attempting to establish complete destruction. It was decided that since it took longer than expected in the work plan to establish destruction, a modified sampling plan containing only the critical parameters needed to gauge performance (ethanol, perchlorate, nitrate, nitrite, phosphorus, ammonia, COD, and bacteriology) should be used. To collect additional samples for other, noncritical parameters (e.g., alkalinity, chloride, sulfate, sulfide, metals) while destruction was still being established was not efficient or economical. Typically, all of the critical parameter analyses were performed on bioreactor influent (C) and effluent (G) samples (except bacteriology, which was performed on G only). For the undiluted samples (BS-C), usually only ethanol, perchlorate, phosphorus, nitrate, and nitrite analyses were performed. Modified Week 1 sampling was performed daily, except when unforeseen circumstances, changes, or interruptions would not allow. Once complete destruction was established, detailed profile samples were collected per the work plan week 2 sampling and analysis plan with the addition of sample collection at the BS-C port. The work plan listed 7 days of profile sampling, but 16 days' worth of profile samples were collected. Once enough profile data had been collected, typically, the modified Week 1 sampling schedule would resume because it contained the critical parameters. The Week 3 through 8 sampling and analysis plan was used during the last 10 days of operation while the ethanol maximum efficiency testing was being performed.

- No hypochlorite analyses were conducted because no EPA test method exists for that analysis.

- At the request of Aerojet, analyses for nitroso-dimethyl-amine were performed on a limited basis.

- VOC analyses per EPA Method 502.2 were conducted because a lower detection limit than that obtainable from EPA Method 8260 was possible. At some points during the study, VOC analyses were conducted more frequently than listed in the work plan to specifically monitor vinyl chloride.

- Because the overall length of the study increased dramatically, the field quality control sample schedule contained in the work plan is not valid. QA/QC samples were collected

APPENDIX C

DETAILED TREATMENT SYSTEM OPERATIONS CHRONOLOGY

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DETAILED TREATMENT SYSTEM OPERATIONS CHRONOLOGY

Pilot plant operations can be divided into two distinct timeframes: operations with higher groundwater influent DO (6 to 8 mg/L) and operations with lower groundwater influent dissolved oxygen (1 to 1.5 mg/L). These timeframes corresponded to when the air stripper was operated on the bioreactor influent and when it was removed from the system. The first portion of pilot plant operations from November 7, 1997, through January 23, 1998 were completed with the air stripper in the influent side of the bioreactor. The air stripper provided influent water with higher DO levels, and complete destruction of perchlorate and nitrate was not achieved consistently. For the second portion of operations from January 24 through March 13, 1998, the influent DO levels were decreased drastically by removing the air stripper. Complete destruction of perchlorate and nitrate was achieved consistently during this time period.

For this report, complete or 100 percent destruction is defined as occurring when the influent concentration of the compound (i.e., perchlorate, nitrate) has been reduced in the effluent to a concentration that is not detectable. Therefore if an influent perchlorate concentration of 50 μg/L is reduced to nondetect (<4 μg/L) in the effluent, the destruction is considered to be 100 percent. To calculate percent destruction, nondetect results were assigned a concentration equal to the detection limit for that compound.

Pilot Plant Operations with Higher Influent Dissolved Oxygen

On November 5, 1997, granular activated carbon and microorganisms were added to the bioreactor and the system operated in 100 percent recirculated water mode at a flow rate of 30 gpm for 2 days. The pilot plant is designed to constantly run at a flow rate of 30 gpm through the bioreactor. System design allows the operators to vary the proportion of groundwater influent and recirculated water. With no input from the well, the system runs with 100 percent recirculated water. Groundwater flow can be increased on a continuum until the pilot plant is running a 0 percent recirculated water component.

Baseline groundwater samples were also collected and analyzed at that time. Forward flow operations began on November 7, 1997, with 83 percent recirculated water. The initial ethanol flow rate was calculated using data derived from the previous perchlorate study. The initial loading rate of the urea and diammonium phosphate nutrient mix was set according to known microbial requirements. The unit was operated at a 83 percent recirculated water for nearly 2 weeks to ensure microorganism attachment to the GAC.

The recirculating water percentage was slowly increased in 17 percent increments. Once complete perchlorate destruction was observed at a step, the flow rate was increased to the next step. To assist microbial growth, batch additions of nitrate were made to the system during this time period. Three weeks after startup, the unit was operating with 33 percent recirculating water. During this time period, samples were collected per the modified Week 1 sampling schedule. Complete destruction of perchlorate to the detection limit was observed with 67, 50, and 33 percent recirculating water but was not consistent. With 83 percent recirculating water, detection of any perchlorate destruction was not possible as the perchlorate concentration entering the bioreactor was diluted by recycle water to below its detection limit. On days of complete perchlorate destruction, at 67, 50, and 33 percent recirculating water, concentrations in the bioreactor influent averaged 8, 9, and 12 μg/L, respectively. The overall average destruction rates at 10, 15, and 20 gpm were 90 percent, 100 percent, and 74 percent, respectively. Note that only one sample set was collected with 50 percent recirculating water.

Complete nitrate destruction to its detection limit was observed with 83, 67, 50, and 33 percent recirculating water but was not consistent. Influent concentrations of nitrate varied widely because of batch nitrate addition. On days when complete nitrate destruction was obtained at 83, 67, 50, and 33 percent recirculating water, the influent nitrate concentrations averaged 0.78, 0.75, 5.3, and 6.3 mg/L, respectively. The overall average destruction rates at 10, 15, and 20 gpm were 42 percent, 100 percent, and 56 percent, respectively. Again note that only one sample set was collected with 50 percent recirculating water.

On days of complete nitrate destruction, effluent values for nitrite, the nitrate degradation product, were all nondetect. On days when nitrate destruction was less than 25 percent, detectable concentrations of nitrite ranging from 0.08 to 0.58 mg/L were observed. It was observed that copious amounts of nitrogen gas bubbles were being created at higher influent groundwater flow rates as a result of the nitrate reduction occurring in the bioreactor. Nitrogen bubbles would attach to granules of carbon/biomass, carrying the carbon/biomass out of the bioreactor. This in turn led to plugging of system piping.

During operations with 67, 50, and 33 percent recirculating water, residual effluent ethanol concentrations were high, ranging from 68 to 370 mg/L. Residual effluent phosphorus levels ranged from 0.1 to 1.3 mg/L. Bioreactor influent values of ethanol and phosphorus varied widely.

During this time period, typical effluent DO values were 0.0 or 0.1 mg/L. The pH both decreased and increased across the bioreactor. The denitrification process is an alkaline process that should increase the pH across the bioreactor. Temperature increases or decreases across the reactor varied from no change to 0.9°C. The average reactor temperature was ORP measurements were not taken during this time as the ORP meter obtained for the study was not functioning properly and a new meter was being ordered.

From December 2 through 4, 1997, a carbon capture tank and return system was installed in the bioreactor effluent pipe to minimize carbon loss from the bioreactor. During the carbon separator installation, it was noted that an unknown white, mucous-like substance had caused carbon granules to clump together in the bioreactor. Such clumping decreases surface area within the bioreactor, thereby potentially decreasing perchlorate and nitrate destruction. This substance had also been encountered during the previous perchlorate study conducted at Aerojet. The extent to which this substance is present appears to be directly related to the amount of excess ethanol added to the system. The presence of the slime also clogged several of the reactor sample ports, making sample collection from these ports impossible on some days. For future operations, the ethanol flow rate was decreased and optimized as much as possible to minimize the presence of the white mucous.

On December 11, 1997, the nutrient source was changed from urea and diammonium phosphate to hexametaphosphate. It was thought that the denitrification process would provide enough elemental nitrogen for use by the microorganisms, so that a nutrient source that provided phosphorus only would be adequate.

After carbon separator installation, the unit was started up with 33 percent recirculating water to see if the biomass could respond immediately and reestablish previous destruction. This was not possible, and so the recirculating water was increased to 83 percent to rebuild the microbial population. Complete perchlorate and nitrate destruction had been obtained at 33 percent recirculating water, and so the recirculating water was decreased to 0 percent to see if complete destruction could be established at that flow rate as well.

While the system operated with 0 percent recirculation, 4 days of reactor profile samples (per Week 2 sampling schedule) were collected. All other samples were collected per the modified Week 1 sampling schedule. Complete perchlorate destruction was never obtained, and destruction averaged 30 percent. The average influent perchlorate concentration was 37 μg/L, and the average effluent concentration was 29 μg/L.

Complete destruction of nitrate was obtained three times, but it could not be established consistently. On the 3 days of complete destruction, the nitrate bioreactor influent concentration averaged 10.6 mg/L. The overall average nitrate destruction was 75 percent. The overall average influent nitrate concentration was 11 mg/L, and the overall average effluent nitrate concentration was 2.9 mg/L. At 30 gpm, only two sample sets had nondetect effluent concentrations of nitrite. The overall average effluent nitrite concentration was 0.32 mg/L.

Influent ethanol concentrations averaged 71 mg/L, while effluent residual concentrations averaged 27 mg/L. Bioreactor influent phosphorus concentrations averaged 0.34 mg/L, while effluent residual phosphorus concentrations averaged 0.21 mg/L.

Profile sampling was not performed for a continuous week, as originally outlined in the work plan, because complete destruction could not be obtained. Until complete destruction was reestablished, no further profile sampling would be performed.

The ORP value in the effluent averaged +74 mV. A value of -200 to -300 mV was expected for typical denitrification processes but would vary with influent groundwater flow rate. The influent and effluent DO, as measured by the inline DO probes, averaged 8.8 and 0.5 mg/L, respectively. The pH increase across the reactor averaged 0.25 pH units. The average temperature change across the reactor was 0.2°C.

Complete destruction of perchlorate and nitrate could not be obtained with 0 percent recirculating water; therefore, the percent of recirculation would be increased in 17 percent increments until complete destruction could be obtained consistently. Complete destruction had been achieved previously with 33 percent recirculating water, and then testing was performed with 0 percent recirculating water. No testing had been conducted with 17 percent recirculation, and so on December 23, 1997, the recirculation was changed to 17 percent. Samples were collected per the modified Week 1 sampling schedule. The complete destruction of nitrate and perchlorate was not obtained. Perchlorate destruction was approximately 32 percent, with influent and effluent concentrations of 35 and 25 μg/L, respectively. Nitrate destruction was approximately 60 percent, with influent and effluent concentrations of 9.5 and 3.9, respectively. Effluent nitrite concentrations averaged 1.2 mg/L. The influent and effluent ethanol concentrations were 57 and 27 mg/L, respectively. The influent and effluent phosphorus concentrations were 0.4 and 0.3 mg/L, respectively. The ORP value in the effluent averaged +28 mV. Influent and effluent DO concentrations, as measured by the inline DO probes, averaged 9 and 0.5 mg/L, respectively. The average pH increase across the reactor was 0.11 pH unit. The average temperature increase across the reactor was negligible.

Since complete perchlorate and nitrate destruction was not obtainable with 17 percent recirculation, the recirculation was increased to 33 percent on December 28, 1997. Since complete destruction had been obtained before at this flow rate on December 1 and 2, 1997, it was anticipated that it would be obtained again. Samples were collected per the modified Week 1 sampling schedule.

From December 29, 1997, to January 23, 1998, complete perchlorate destruction was obtained only once, with the destruction averaging 34 percent. The overall average influent and effluent concentrations were 33 and 23 μg/L, respectively.

Complete nitrate destruction was never obtained. Nitrate destruction averaged 79 percent, with the average influent and effluent concentrations at 11 and 2.5 μg/L, respectively. The average effluent nitrite concentration was 0.60 mg/L, with only one sample result below the standard detection limit.

At the time, it was thought that one potential reason that complete perchlorate and nitrate destruction could not be established was the loss of carbon out of the bioreactor. Due to carbon carryover the settled bed height, which began at 7 feet, had decreased to 5 1/2 feet. Carbon was added to the reactor to bring the settled bed height back to its original height. Samples collected soon after showed that this addition of carbon had no effect on destruction. For the remainder of the study, the settled bed height was checked routinely and carbon was added when needed.

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Ethanol influent and effluent concentrations averaged 177 and 156 mg/L, respectively. The ethanol addition rate was increased to see if this would help achieve complete reduction of both nitrate and perchlorate since previous performance with 33 percent recirculation had been achieved at high ethanol loading rates. The increased ethanol led to the generation of additional mucous but did not improve destruction. The bioreactor had to be probed regularly to break apart coagulated mucous and carbon and to ensure that the bed fluidization properties were as good as possible.

At that time it was thought that a potential reason for not establishing complete destruction was that the hexametaphosphate nutrient mix did not provide enough elemental nitrogen to support the microorganisms as was originally anticipated. The hexametaphosphate source was removed and replaced with the original nutrient source of urea and diammonium phosphate on December 31, 1997. However, the change in nutrients did not improve destruction. After switching to the original nutrient source, influent and effluent phosphorus concentrations averaged 0.43 and 0.42 mg/L, respectively.

The ORP value in the effluent averaged -103 mV. From January 13 through 23, 1998, the ORP rose to an average of -209 mV; however, nitrate or perchlorate destruction did not improve. DO influent and effluent concentrations, as measured by inline DO probes, averaged 5.6 and 0.3 mg/L, respectively. When complete destruction was obtained previously with 33 percent recirculation, effluent DO concentrations averaged 0.05 mg/L. The average pH increase across the reactor was 0.23 pH unit. The average temperature increase across the reactor was negligible.

Near the end of the operation, it was decided that DO profiles within the reactor would be taken to see where most of the DO was being depleted. A DO profile was completed by directly lowering the DO probe inside the reactor and recording DO concentrations as the probe traversed from the bottom to the top of the reactor. While this was done temperature measurements were also taken with the DO probe as they would be more accurate than temperature measurements taken through the D, E, and F sampling ports.

Pilot Plant Operations with Lower Influent Dissolved Oxygen

After ruling out ethanol and nutrient addition and proper bed fluidization as potential reasons for the nonattainment of complete destruction with 33 percent recirculation, it was thought that another potential reason might be that the DO loading might be too high for the biomass to handle. It was thought that with high DO there might not be enough residence time in the bioreactor for the biomass to utilize all of the DO and destroy all of the nitrate and perchlorate. To test this theory, the air stripper was taken offline on January 24, 1998, effectively decreasing the undiluted influent DO from a range of 8 to 10 mg/L to a range of 9.5 to 1 mg/L.

With the air stripper removed, the recirculation was set at 33 percent on January 24, 1998. Samples were collected per the modified Week 1 sampling schedule. Complete nitrate and perchlorate destruction was obtained within 2 days. For the next 3 days, perchlorate destruction averaged 100 percent. The average influent perchlorate concentration was 28 μg/L.

The nitrate destruction also averaged 100 percent. The average influent nitrate concentration was 10.7 mg/L. The overall average effluent nitrite concentration was 0.05 mg/L.

The influent ethanol concentrations averaged 110 mg/L, while effluent residual concentrations averaged 96 mg/L. Bioreactor influent phosphorus concentrations averaged 0.52 mg/L, while effluent residual phosphorus concentrations averaged 0.42 mg/L.

The ORP value in the effluent averaged -228 mV. The influent and effluent DO, as measured by inline DO probes, averaged 0.7 and 0.1 mg/L, respectively. The pH increase across the reactor averaged 0.56 pH unit. The average temperature change across the reactor was negligible.

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With complete perchlorate and nitrate destruction achieved with 33 percent recirculating water, the recirculation was decreased to 17 percent on January 28, 1998. Samples were collected per the modified Week 1 and Week 2 profile sampling schedules. Six sets of profile samples were collected on different days from January 28 to February 6, 1998.

Complete nitrate and perchlorate destruction was obtained within 1 day after reducing the recirculating water. For the next 8 days, perchlorate destruction averaged 100 percent. The average influent perchlorate concentration was 28 $\mu g/L$.

The nitrate destruction also averaged 100 percent. The average influent nitrate concentration was 14.4 mg/L. Nitrite was nondetect, at the standard detection limit of 0.03 mg/L, in every bioreactor effluent sample collected over this time period.

The influent ethanol concentrations averaged 86 mg/L, while effluent residual concentrations averaged 27 mg/L. Bioreactor influent phosphorus concentrations averaged 0.68 mg/L, while effluent residual phosphorus concentrations averaged 0.46 mg/L.

The ORP value in the effluent averaged -298 mV. The influent and effluent DO, as measured with the hand-held DO probe inside the bioreactor, averaged 0.45 and 0.09 mg/L, respectively. The pH increase across the reactor averaged 0.58 pH unit. The average temperature change across the reactor was negligible.

With complete perchlorate and nitrate destruction established regularly, particular attention was now paid to how the biomass would affect chlorinated VOCs (e.g., TCE, 1,1-DCE) traveling through the bioreactor. It was unsure how VOCs would be destroyed and whether or not highly toxic VOCs such as vinyl chloride would be generated as a result of interaction with the biomass. No detectable concentrations (at a detection limit of 0.1 $\mu g/L$) of vinyl chloride were present in any effluent sample collected over this time period. Chlorinated VOCs were regularly reduced to varying degrees by either adsorption to the carbon, biomass activity, or a combination of the two. The degree of the role that both carbon adsorption and biomass degradation play in the reduction of VOCs is unknown at this time. Further study to explore this issue is currently underway, and the results of that study will be provided in an addendum to this report.

The successful run with 17 percent recirculating water was cut short when a storm caused a major power outage at the site on February 7, 1998. The unit remained completely shut down until power was restored to site on February 10, 1998.

Once power was restored to the site, the system was started up again, and the recirculating water was gradually decreased from 50 to 17 percent. For the next month the system was operated with recirculating water at 17 percent. The majority of samples were collected per the modified Week 1 and Week 2 profile sample schedules (six sets of profiles were collected). During the last 2 weeks of operations, testing was conducted to find the point at which complete destruction was lost after continually reducing the ethanol addition rate. During this testing, the Weeks 3 through 8 sample schedule listed in the work plan was used.

Within 2 days after startup, complete destruction of perchlorate and nitrate was obtained with 33 percent recirculation. The recirculation was then decreased to 17 percent, where it remained. Within 1 day of the change in flow rate, complete destruction was achieved with 17 percent recirculation. The unit had to be shut down again over another weekend on February 21 and 22, 1998, due to Aerojet construction. The unit was restarted on February 23, 1998, and samples were collected approximately 2 and 8 hours after startup. Complete nitrate destruction was observed in both samples; however, complete perchlorate destruction was observed only in the 2-hour sample. The 8-hour effluent sample perchlorate result rose slightly above the detection limit to 5 μg/L.

From February 13 through March 1, 1998, perchlorate destruction averaged 99 percent with 17 percent recirculation. Complete perchlorate destruction was not obtained on three occasions, when the effluent concentration rose slightly above the detection limit to 5.1 μg/L once and 5.5 μg/L twice. The average influent perchlorate concentration was 38 μg/L, and the average effluent concentration was 4.4 μg/L (assuming a concentration equal to that of the detection limit for nondetect results).

Nitrate destruction averaged 100 percent over this period of time. The average influent nitrate concentration was 12.8 mg/L. Nitrite was nondetect, at the standard detection limit of 0.03 mg/L, in every bioreactor effluent sample collected over this time period.

Influent ethanol concentrations averaged 83 mg/L, while effluent residual concentrations averaged 8 mg/L. Bioreactor influent phosphorus concentrations averaged 0.63 mg/L, while effluent residual phosphorus concentrations averaged 0.49 mg/L.

The ORP value in the effluent averaged -280 mV. The influent and effluent DO, as measured with the hand-held DO probe inside the bioreactor, averaged 0.43 and 0.14 mg/L, respectively. The pH increase across the reactor averaged 0.44 pH unit. The average temperature change across the reactor was negligible.

On February 25, 1998, the ethanol loading rate began to be reduced to find the point at which complete perchlorate and nitrate destruction would be lost. This was done in an attempt to maximize destruction while minimizing the ethanol usage and the concentration of ethanol in the system effluent. By March 3, 1998, complete perchlorate destruction had been lost, slipping to 92 percent. As the reactor influent concentration of ethanol was decreased to approximately 50 mg/L, complete perchlorate (and soon after nitrate) destruction was lost. Therefore, the range of ethanol concentrations at which complete perchlorate and nitrate destruction is lost lies between 50 to 70 mg/L. The ethanol was then promptly increased in an attempt to re-establish complete destruction. This attempt was aborted because the air stripper had to be brought back online to remove VOCs from the groundwater as Aerojet's groundwater treatment system at the treatment pond was shut down. The overall average perchlorate destruction during the ethanol testing was 85 percent, with average influent and effluent concentrations of 39 and 9 μg/L, respectively.

Complete nitrate destruction was re-established over the last 3 days of sampling. Even at the worst point, destruction had slipped only to 98.9 percent during this testing. The overall average nitrate destruction during the ethanol testing was 99.7 percent, with the average influent concentrations at 13 and 0.14 mg/L (assuming a concentration equal to the detection limit for nondetect results) respectively. The average nitrite concentration rose during this testing to 0.21 mg/L.

Once complete destruction was lost and the ethanol was increased again, the influent ethanol concentration averaged 88 mg/L, while the effluent residual concentration averaged 24 mg/L. While attempting to reestablish complete destruction, influent phosphorus concentrations averaged 0.62 mg/L and effluent residual phosphorus concentrations averaged 0.45 mg/L.

Once complete destruction was lost, the ORP value in the effluent dropped to an average of -185 mV. The influent and effluent DO, as measured with the hand-held DO probe inside the bioreactor, averaged 0.40 and 0.09 mg/L, respectively. The pH increase across the reactor averaged 0.86 pH unit. The average temperature change across the reactor was negligible.

Even though complete perchlorate destruction was not re-established, at the time operations were ceased to bring the air stripper back online, the effluent nitrite had slowly decreased to nondetect and the

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effluent ORP was increasing. By March 13, 1998, the effluent ORP was -228 mV with an increasing trend toward the average ORP value of -280 mV, observed when complete perchlorate destruction was being obtained prior to the initiation of ethanol testing.

Schedule allowing, additional testing to further resolve the most efficient ethanol influent concentration and hence addition rate will be conducted at the end of this study.

APPENDIX D

LABORATORY ANALYTICAL DATA SUMMARY

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

SAMPLING PORT	DATE SAMPLED	11/5/97	11/6/97	11/7/97	11/8/97	11/9/97	11/10/97	11/11/97	11/12/97	11/13/97	11/14/97	11/15/97	11/15/97 Even.	11/16/97	11/16/97 Even.	11/17/97	11/17/97 Even.
	INFLUENT GW FLOWRATE (GPM)	-	-	5.1	-	3.8	3.6	3.5	4.1	3.8	4.0	3.8	-	3.9	-	4.0	-
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	94	-	32	17	21	30	33	<10	<10	-	<10	-	<10	-
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	61	-	24	20	24	22	23	<10	<10	-	<10	-	<10	-
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Perchlorate (ug/l)	-	-	<4	-	<4	<4	<4	<4	<4	<4	<4	-	<4	-	<4	-
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Perchlorate (ug/l)	-	-	<4	-	<4	<4	<4	<4	<4	<4	<4	-	<4	-	<4	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	<2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	<0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Phosphorus (mg/l)	-	-	1.60	-	1.10	1.30	1.30	0.91	14.00	2.30	2.40	-	8.40	-	3.60	-
Reactor Effluent (G)	Total Phosphorus (mg/l)	-	-	1.60	-	1.20	1.30	1.20	0.88	13.00	2.30	2.70	-	6.70	-	3.50	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	2.70	-	0.15	0.48	0.26	0.41	0.46	9.60	4.10	-	15.00	-	2.50	-
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	2.80	-	<0.1	0.17	0.29	0.19	0.21	8.90	3.60	-	2.20	-	3.70	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	13.0	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	10	-	3.3	<0.1	<0.1	<0.1	0.63	11	8.4	1.8	<0.1	2.1	4.3	2.0
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	11	-	2.2	<0.1	<0.1	<0.1	<0.1	10	7.5	2.6	0.46	0.48	3.3	2.6
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	0.19	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	0.21	-	0.13	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	0	absent	0	-	-	0	-	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	absent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	2.0	present	1.0	-	-	-	-	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	1027	2783	3630	-	-	8730	-	9970	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	<1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	<3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	<10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	210	-	81	120	81	88	86	11	<10	-	29	-	<10	-
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	210	-	70	72	72	79	97	11	<10	-	11	-	<10	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	11/18/97	11/18/97 Even.	11/19/97	11/19/97 Even.	11/20/97	11/21/97	11/22/97	11/23/97	11/24/97	11/25/97	11/26/97	11/27/97	11/28/97	11/29/97	11/30/97	12/1/97
	INFLUENT GW FLOWRATE (GPM)	4.3	-	4.4	-	10.1	9.8	-	-	10.9	10.6	15.2	-	20.1	-	20.2	20.7
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	30	-	180	-	200	94	-	-	46	51	120	-	<10	-	440	220
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	33	-	-	-	130	23	-	-	34	59	110	-	<10	-	460	120
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	21	-	-	-	180	<10	-	-	<10	<10	68	-	<10	-	370	120
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Perchlorate (ug/l)	<4	-	<4	-	<4	7.6	-	-	8.1	11	9	-	<4	-	<4	9.9
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Perchlorate (ug/l)	<4	-	<4	-	<4	<4	-	-	<4	6.2	<4	-	<4	-	<4	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Phosphorus (mg/l)	0.94	-	3.1	-	1.3	0.33	-	-	0.41	0.46	0.48	-	0.46	-	0.65	0.14
Reactor Effluent (G)	Total Phosphorus (mg/l)	1.1	-	3.7	-	1.3	0.27	-	-	0.37	0.38	0.36	-	0.77	-	0.48	0.10
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	<0.1	-	0.63	-	0.26	0.19	-	-	<0.1	<0.1	0.10	-	0.77	-	0.13	0.11
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	<0.1	-	0.47	-	0.12	0.10	-	-	<0.1	<0.1	<0.1	-	1.00	-	0.15	<0.1
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	-	-	-	-	9.2	12	-	-	11	12	12	-	12	-	15	11
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	0.22	<0.1	1.3	0.97	0.75	4.5	-	-	8.9	9.4	5.30	-	8.90	-	<0.1	5.9
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	-	-	7.8	7.9	<0.1	-	6.70	-	<0.1	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	<0.03	-	-	<0.03	<0.03	<0.03	-	<0.03	-	<0.03	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03	0.13	-	-	0.10	0.25	0.07	-	0.33	-	<0.03	<0.03
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	0.08	0.34	<0.03	-	0.58	-	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	-	absent	-	0	-	-	-	0	0	0	-	-	-	1	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	3.1	-	present	-	8.7	-	-	-	2.0	9.9	2.0	-	-	-	>200.5	1.0
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	2739	-	7300	-	5382	-	-	-	2373	1816	1375	-	-	-	5381	2372
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	<10	-	140	-	200	53	-	-	55	53	160	-	11	-	600	270
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	<10	-	140	-	190	51	-	-	<10	<10	130	-	14	-	590	260
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

SAMPLING PORT	DATE SAMPLED	12/2/97	12/3/97	12/4/97	12/5/97	12/6/97	12/7/97	12/8/97	12/9/97	12/10/97	12/11/97	12/12/97	12/13/97	12/14/97	12/15/97	12/16/97	12/17/97
	INFLUENT GW FLOWRATE (GPM)	19.6	-	-	20.5	20.0	-	-	5.0	-	29.9	29.9	29.4	29.6	29.0	29.4	30.0
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	140	-	-	130	110	-	-	190	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	140	-	-	110	110	-	-	200	-	87	84	48	50	78	82.0	84.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.0
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	100	-	-	100	78	-	-	190	-	37	50	<10	<10	12	-	7.2
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	-	50	49	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Perchlorate (ug/l)	14	-	-	55	44	-	-	-	-	41	39	40	40	36	42.0	34.0
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31.0
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<4
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.0
Reactor Effluent (G)	Perchlorate (ug/l)	<4	-	-	36.0	<20	-	-	-	-	27	34	40	29	24	25.0	26.0
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.074/<0.02	0.078/<0.02
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.054/<0.02	0.048/<0.02
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	0.04/<0.02
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.02/<0.02	0.043/<0.02
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.9
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.8
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Phosphorus (mg/l)	0.20	-	-	0.17	0.54	-	-	-	-	<0.05	0.46	0.28	0.27	0.26	0.25	0.25
Reactor Effluent (G)	Total Phosphorus (mg/l)	0.10	-	-	0.10	0.69	-	-	-	-	<0.05	0.37	0.15	0.17	0.15	0.13	0.15
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	0.32	-	-	0.31	0.28	-	-	-	-	0.14	<0.1	<0.1	<0.1	<0.1	0.20	<0.1
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.21	-	-	0.45	0.28	-	-	-	-	0.82	0.11	<0.1	<0.1	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	11	-	-	11	10	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	6.6	-	-	8.2	9.8	-	-	-	-	11	14	0.21	13	13	11.00	10.00
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	-	-	7.1	5.7	-	-	-	-	7.9	9.5	2	<0.1	0.64	0.55	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	<0.03	-	-	<0.03	<0.03	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	0.08	-	-	0.15	<0.03	-	-	-	-	0.04	<0.03	0.051	<0.03	<0.03	<0.03	0.12
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.03
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.03
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.03
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	-	-	0.5	<0.03	-	-	-	-	0.53	0.33	1.6	0.034	0.18	0.17	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.0	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.0	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	-	-	0	-	-	-	-	-	0	0	-	0	1	0	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	-
Reactor Effluent (G)	Coliform (MPN/100ml)	2.0	-	-	2.0	-	-	-	-	-	1.0	1.0	-	0.0	1.0	1.0	0.0
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	373	-
Reactor Effluent (G)	Bacteria (CFU/ml)	2164	-	-	1306	-	-	-	-	-	760	320	-	1237	1118	571	1012
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	260.0	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	410	-	-	130	110	-	-	-	-	100	120	110	91	100	-	87.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80.0
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	96.0
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54.0
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	410	-	-	110	87	-	-	-	-	98	98	69	52	52	52.0	56.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

DRAFT

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	12/18/97	12/19/97	12/20/97	12/21/97	12/22/97	12/23/97	12/24/97	12/25/97	12/26/97	12/27/97	12/28/97	12/29/97	12/30/97	12/31/97	1/1/98	1/2/98
	INFLUENT GW FLOWRATE (GPM)	29.4	28.3	28.6	28.9	29.0	29.1	25.1	-	24.0	-	20.0	20.1	20.6	20.3	-	19.5
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	64.0	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	65.0	<5	110.0	75.0	82.0	-	57.0	-	59.0	-	-	88.0	-	61.0	-	61.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	24.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	<5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	20.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	<5	30.0	73.0	34.0	47.0	-	27.0	-	27.0	-	-	55.0	-	28.0	-	44.0
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	<5	<5	-	11.0	12.0	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	<5	-	11.0	11.0	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	-	-	-	-	34.0	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Perchlorate (ug/l)	35.0	34.0	34.0	35.0	38.0	-	35.0	-	-	-	-	35.0	-	31.0	-	34.0
Reactor 1/4 (D)	Perchlorate (ug/l)	31.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Perchlorate (ug/l)	<4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Perchlorate (ug/l)	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Perchlorate (ug/l)	28.0	30.0	30.0	26.0	26.0	-	25.0	-	28.0	-	-	23.0	-	19.0	-	23.0
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	<0.02/0.075	<0.02/0.074	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	<0.02/0.031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	<0.02/0.041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	<0.02/<0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	<0.02/<0.02	<0.02/<0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	140.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	6.8	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chloride (mg/l)	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	6.8	6.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Phosphorus (mg/l)	0.41	0.47	0.43	0.34	0.27	-	0.40	-	-	-	-	0.18	-	0.16	-	0.31
Reactor Effluent (G)	Total Phosphorus (mg/l)	0.27	0.27	0.31	0.21	0.17	-	0.30	-	-	-	-	0.13	-	0.09	-	0.16
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	<0.1	<0.1	<0.1	-	<0.1	-	<0.1	-	-	-	-	<0.1	-	<0.1	-	0.27
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	<0.1	<0.1	<0.1	-	<0.1	-	<0.1	-	-	-	-	<0.1	-	<0.1	-	0.11
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	13.00	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	11.00	8.90	10.00	-	10.00	-	9.50	-	-	-	-	12.00	-	13.00	-	9.70
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	4.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	2.40	<0.1	3.90	-	4.70	-	3.90	-	3.30	-	-	3.70	-	2.40	-	1.70
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	<0.03	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	-	-	-	0.12	-	-	-	-	0.27	-	0.35	-	0.27
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.26	<0.03	0.28	-	-	-	0.76	-	1.60	-	-	0.76	-	0.35	-	0.87
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	12/<1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	16/<1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	1.0	-	-	-	0.0	-	3.1	-	-	-	-	5.3	-	0.0	-	0.0
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	2704	-	-	-	1320	-	12480	-	-	-	-	1780	-	1280	-	1063
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	300.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	260.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	<5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	<5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	110.0	<10	200.0	-	150.0	-	100.0	-	-	-	-	130.0	-	-	-	170.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	69.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	120.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	65.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	74.0	56.0	120.0	-	120.0	-	63.0	-	-	-	-	110.0	-	98.0	-	110.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

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Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	1/3/98	1/4/98	1/5/98	1/6/98	1/7/98	1/8/98	1/9/98	1/10/98	1/11/98	1/12/98	1/13/98	1/14/98	1/15/98	1/16/98	1/17/98	1/18/98
	INFLUENT GW FLOWRATE (GPM)	20.7	-	19.5	20.0	20.8	20.1	20.0	20.0	19.0	19.2	19.5	19.2	19.8	20.0	-	20.1
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	-	-	-	-	220.0	-	260.0	300.0	-	260.0	-	180.0	240.0	280.0	-	170.0
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	67.0	-	220.0	-	180.0	240.0	-	270.0	-	210.0	240.0	220.0	-	140.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	42.0	-	200.0	-	200.0	210.0	-	310.0	-	190.0	190.0	180.0	-	130.0
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	11.0	-	15.0	10.0	-	17.0	-	5.4	5.1	-	-	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	-	-	11.0	-	12.0	12.0	-	13.0	-	5.9	5.8	-	-	5.8
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	-	-	10.0	-	16.0	9.5	-	8.9	-	5.8	6.1	5.2	-	6.4
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	-	-	37.0	-	36.0	38.0	-	36.0	-	42.0	36.0	37.0	-	40.0
Reactor Influent (C)	Perchlorate (ug/l)	-	-	39.0	-	31.0	-	38.0	35.0	-	28.0	-	36.0	37.0	33.0	-	<4
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Perchlorate (ug/l)	-	-	26.0	-	20.0	-	14.0	18.0	-	21.0	-	25.0	19.0	20.0	-	21.0
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	0.12	-	0.10	0.11	-	0.12	-	0.12	0.10	0.12	-	0.10
Reactor Influent (C)	Total Phosphorus (mg/l)	-	-	0.27	-	0.27	-	0.09	0.08	-	0.12	-	0.60	0.48	0.22	-	0.97
Reactor Effluent (G)	Total Phosphorus (mg/l)	-	-	0.13	-	0.14	-	0.05	0.08	-	0.08	-	0.25	0.27	0.41	-	2.30
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	0.19	-	0.29	-	<0.1	0.12	-	0.21	-	0.99	0.56	0.56	-	0.72
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	<0.1	-	0.12	-	<0.1	0.10	-	<0.1	-	0.13	0.19	0.13	-	0.73
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	-	-	-	-	13.00	-	14.00	15.00	-	15.00	-	14.00	17.00	17.00	-	17.00
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	10.00	-	11.00	-	11.00	9.70	-	12.00	-	14.00	12.00	12.00	-	<0.1
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	1.50	-	0.90	-	2.50	<0.1	-	2.20	-	1.80	2.40	2.30	-	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	-	-	-	-	<0.03	-	<0.1	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	-	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	0.12	-	0.12	-	0.25	0.18	-	0.20	-	0.19	0.17	0.22	-	<0.03
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	0.29	-	0.28	-	0.66	0.52	-	0.52	-	0.56	0.51	0.59	-	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	0	-	-	-	-	-	-	-	0	-	-	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	12.4	-	-	-	-	-	-	-	8.7	0.0	-	>200.5
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	1101	-	-	-	-	-	-	-	4319	5723	-	6786
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	130.0	-	380.0	-	430.0	230.0	-	360.0	-	370.0	430.0	370.0	-	360.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	110.0	-	350.0	-	430.0	220.0	-	200.0	-	330.0	400.0	430.0	-	390.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

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Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	1/19/98	1/20/98	1/21/98	1/22/98	1/23/98	1/24/98	1/25/98	1/26/98	1/27/98	1/28/98	1/29/98	1/30/98	1/31/98	2/1/98	2/2/98	2/3/98
	INFLUENT GW FLOWRATE (GPM)	19.5	19.5	20.0	-	20.6	20.2	19.8	20.0	20.0	25.0	25.0	25.5	25.8	25.9	25.0	24.2
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	220.0	260.0	200.0	-	150.0	-	100.0	120.0	120.0	100.0	110.0	83.0	-	-	99.0	120.0
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	260.0	230.0	230.0	-	110.0	-	110.0	100.0	120.0	110.0	98.0	71.0	-	100.0	95.0	97.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	68.0	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	37.0	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	200.0	220.0	220.0	-	75.0	-	84.0	81.0	120.0	55.0	53.0	30.0	-	20.0	18.0	23.0
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	5.8	<5	-	<5	-	<5	<5	<5	<5	<5	<5	-	<5	<5	<5
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	5.3	5.7	-	<5	-	<5	<5	<5	<5	<5	<5	-	<5	<5	<5
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	5.6	5.3	5.3	-	<5	-	<5	<5	<5	<5	<5	<5	-	<5	<5	<5
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	43.0	44.0	40.0	-	53.0	-	48.0	52.0	54.0	51.0	36.0	25.0	-	-	57.0	35.0
Reactor Influent (C)	Perchlorate (ug/l)	30.0	29.0	38.0	-	28.0	-	36.0	21.0	27.0	33.0	<4	18.0	-	20.0	29.0	35.0
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	<4	-	-	<4	<4	<4
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	<4	-	-	<4	<4	<4
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	<4	-	-	<4	<4	<4
Reactor Effluent (G)	Perchlorate (ug/l)	31.0	31.0	33.0	-	22.0	-	<4	<4	<4	<4	<4	<4	-	<4	<4	<4
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	100.0	-	-	-	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	110.0	-	-	-	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	150.0	-	-	-	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	9.5	-	-	-	-	-
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	8.5	-	-	-	-	-
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	8.0	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	7.3	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	7.5	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	8.5	-	-	-	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	0.08	0.10	0.10	-	0.11	-	0.10	0.09	0.10	0.10	0.11	0.09	-	-	0.09	0.10
Reactor Influent (C)	Total Phosphorus (mg/l)	0.93	0.56	0.50	-	0.61	-	0.47	0.49	0.59	0.78	0.62	0.84	-	0.75	0.53	0.57
Reactor Effluent (G)	Total Phosphorus (mg/l)	0.71	0.38	0.43	-	0.48	-	0.37	0.42	0.46	0.54	0.43	0.60	-	0.53	0.34	0.35
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	0.82	0.58	0.60	-	0.53	-	0.59	0.80	0.98	0.73	0.59	0.78	-	0.66	0.51	0.59
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	0.58	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	0.52	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	0.55	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.96	0.77	0.79	-	0.51	-	0.82	1.10	1.40	0.70	0.57	0.55	-	0.54	0.29	0.44
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	17.00	18.00	15.00	-	17.00	-	18.00	17.00	22.00	17.00	17.00	22.00	-	-	18.00	17.00
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	13.00	14.00	12.00	-	11.00	-	10.00	11.00	11.00	16.00	14.00	14.00	-	16.00	15.00	14.00
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	0.66	-	-	<0.1	<0.1	2.60
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	1.40	-	-	<0.1	-	<0.1
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.1	-	-	<0.1	<0.1	<0.1
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	4.70	6.50	6.50	-	0.92	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	<0.03	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	<0.03	<0.03	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	0.23	0.41	0.39	-	0.14	-	<0.03	0.05	0.12	0.04	<0.03	<0.03	-	<0.03	<0.03	<0.03
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	0.32	-	-	<0.03	<0.03	0.61
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.03	-	-	<0.03	<0.03	<0.03
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	<0.03	-	-	<0.03	<0.03	<0.03
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	0.76	0.99	1.10	-	0.37	-	<0.03	<0.03	0.10	<0.03	<0.03	<0.03	-	<0.03	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	16 / <1	-	-	-	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	16 / <1	-	-	-	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	15 / <1	-	-	-	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	0	0	-	-	-	-	0	-	0	0	-	-	-	0	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	6.4	-	-	-	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	1.0	1.0	49.2	-	-	-	-	34.4	-	42.9	13.7	>200.5	-	-	>200.5	>200.5
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	373	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	6011	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	6786	5100	60	-	-	-	-	6923	-	3113	7321	952	-	-	5311	7321
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	300.0	-	-	-	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	300.0	-	-	-	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	280.0	-	-	-	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	270.0	-	-	-	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	440.0	450.0	450.0	-	230.0	-	300.0	330.0	320.0	300.0	300.0	200.0	-	240.0	280.0	350.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	390.0	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	250.0	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	230.0	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	450.0	450.0	420.0	-	190.0	-	270.0	290.0	280.0	250.0	240.0	170.0	-	190.0	160.0	300.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

DRAFT

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	2/4/98	2/5/98	2/6/98	2/7/98	2/8/98	2/9/98	2/10/98	2/11/98	2/12/98	2/13/98	2/14/98	2/15/98	2/16/98	2/17/98	2/18/98	2/19/98
	INFLUENT GW FLOWRATE (GPM)	26.4	25.1	24.9	24.5	0.0	0.0	0.0	14.0	25.0	25.1	-	25.2	-	25.2	25.6	25.1
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	110.0	-	92.0	-	-	-	-	120.0	120.0	87.0	-	130.0	-	96.0	96.0	110.0
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	76.0	-	40.0	-	-	-	-	-	86.0	85.0	-	96.0	-	100.0	82.0	84.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	36.0	-	<5	-	-	-	-	-	-	-	-	-	-	40.0	37.0	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	7.4	-	<5	-	-	-	-	-	-	-	-	-	-	<5	<5	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	19.0	-	<5	-	-	-	-	-	-	-	-	-	-	<5	<5	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	14.0	-	<5	-	-	-	-	-	24.0	19.0	-	13.0	-	6.2	7.6	10.0
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	<5	-	<5	-	-	-	-	<5	-	<5	-	<5	-	-	-	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	<5	-	<5	-	-	-	-	-	-	-	-	<5	-	<5	<5	<5
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	-	<5	-	-	-	-	-	-	-	-	<5	-	<5	<5	<5
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	28.0	-	38.0	-	-	-	-	-	39.0	27.0	-	36.0	-	41.0	38.0	48.0
Reactor Influent (C)	Perchlorate (ug/l)	27.0	-	41.0	-	-	-	-	-	30.0	29.0	-	30.0	-	41.0	33.0	47.0
Reactor 1/4 (D)	Perchlorate (ug/l)	13.0	-	17.0	-	-	-	-	-	-	-	-	<4	-	12.0	13.0	-
Reactor 1/2 (E)	Perchlorate (ug/l)	<4	-	<4	-	-	-	-	-	-	-	-	<4	-	<4	<4	-
Reactor 3/4 (F)	Perchlorate (ug/l)	<4	-	<4	-	-	-	-	-	-	-	-	<4	-	<4	5.6	-
Reactor Effluent (G)	Perchlorate (ug/l)	<4	-	<4	-	-	-	-	-	<4	<4	-	<4	-	5.1	<4	5.5
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	110.0	-	100.0	-	-	-	-	-	-	-	-	-	-	100.0	100.0	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	120.0	-	120.0	-	-	-	-	-	-	-	-	-	-	110.0	100.0	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	150.0	-	150.0	-	-	-	-	-	-	-	-	-	-	150.0	150.0	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	9.0	-	8.5	-	-	-	-	-	-	-	-	-	-	8.2	9.5	-
Reactor Influent (C)	Chloride (mg/l)	7.5	-	5.0	-	-	-	-	-	-	-	-	-	-	8.0	7.5	-
Reactor 1/4 (D)	Chloride (mg/l)	7.0	-	8.2	-	-	-	-	-	-	-	-	-	-	7.3	8.0	-
Reactor 1/2 (E)	Chloride (mg/l)	9.5	-	7.2	-	-	-	-	-	-	-	-	-	-	16.0	9.3	-
Reactor 3/4 (F)	Chloride (mg/l)	9.3	-	8.0	-	-	-	-	-	-	-	-	-	-	8.5	7.7	-
Reactor Effluent (G)	Chloride (mg/l)	10.0	-	7.2	-	-	-	-	-	-	-	-	-	-	10.0	7.3	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	0.12	-	0.10	-	-	-	-	-	0.10	0.11	-	0.09	-	0.10	0.11	0.42
Reactor Influent (C)	Total Phosphorus (mg/l)	0.79	-	0.52	-	-	-	-	-	0.62	0.17	-	0.39	-	1.00	1.60	0.87
Reactor Effluent (G)	Total Phosphorus (mg/l)	0.55	-	0.34	-	-	-	-	-	0.40	0.62	-	0.21	-	0.85	1.10	0.59
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	0.16	-	<0.1	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	0.72	-	0.62	-	-	-	-	-	0.93	0.92	-	0.39	-	1.30	0.94	0.75
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	0.62	-	0.73	-	-	-	-	-	-	-	-	-	-	4.80	2.80	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	0.60	-	0.61	-	-	-	-	-	-	-	-	-	-	8.90	6.40	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	0.59	-	0.64	-	-	-	-	-	-	-	-	-	-	8.50	4.30	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.73	-	0.75	-	-	-	-	-	1.00	1.10	-	0.16	-	7.90	4.70	0.76
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	16.00	-	19.00	-	-	-	-	-	13.00	13.00	-	14.00	-	14.00	12.00	14.00
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	13.00	-	14.00	-	-	-	-	-	8.00	11.00	-	13.00	-	12.00	11.00	13.00
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	0.41	-	2.60	-	-	-	-	-	-	-	-	<0.1	-	0.25	0.70	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	<0.1	-	<0.1	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	<0.1	-	<0.1	-	-	-	-	-	-	-	-	<0.1	-	<0.1	<0.1	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	-	<0.1	-	-	-	-	-	<0.1	<0.1	-	<0.1	-	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.03	-	-	-	-	-	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.03	-	-	-	-	-	0.14	<0.03	-	<0.03	-	<0.03	<0.03	<0.03
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	0.36	-	0.51	-	-	-	-	-	-	-	-	<0.03	-	<0.03	0.03	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.03	-	-	-	-	-	-	-	-	<0.03	-	<0.03	<0.03	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.03	-	-	-	-	-	-	-	-	<0.03	-	<0.03	<0.03	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	-	<0.03	-	-	-	-	-	<0.03	<0.03	-	<0.03	-	<0.03	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	16/<1	-	17/<1	-	-	-	-	-	-	-	-	-	-	16/<1.0	16/<1	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	15/<1	-	15/<1	-	-	-	-	-	-	-	-	-	-	16/<1.0	15/<1	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	11/<1	-	11/<1	-	-	-	-	-	-	-	-	-	-	16/<1.0	15/<1	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-	>200.5	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	88.5	-	109.4	-	-	-	-	-	-	-	-	-	-	>200.5	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	>200.5	-	25.4	-	-	-	-	-	>200.5	>200.5	-	-	-	0.0	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	874	-	590	-	-	-	-	-	-	-	-	-	-	2279	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	4721	-	509	-	-	-	-	-	-	-	-	-	-	2311	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	3511	-	18	-	-	-	-	-	3720	1375	-	-	-	1721	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	310.0	-	-	-	-	-	-	-	-	-	-	-	-	270.0	300.0	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	290.0	-	-	-	-	-	-	-	-	-	-	-	-	280.0	290.0	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	260.0	-	-	-	-	-	-	-	-	-	-	-	-	280.0	250.0	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	<5	-	<5	-	-	-	-	-	-	-	-	-	-	<5	<5	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	<5	-	<5	-	-	-	-	-	-	-	-	-	-	<5	<5	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	11.0	-	6.0	-	-	-	-	-	-	-	-	-	-	6.7	<5	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	2.0	-	<1	-	-	-	-	-	-	-	-	-	-	<1	-	-
Reactor Influent (C)	Turbidity (NTU)	4.5	-	1.8	-	-	-	-	-	-	-	-	-	-	3.5	-	-
Reactor Effluent (G)	Turbidity (NTU)	18.0	-	13.0	-	-	-	-	-	-	-	-	-	-	25.0	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	87.0	-	-	-	-	-	-	-	-	-	-	-	81.0	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	54.0	-	-	-	-	-	-	-	-	-	-	-	83.0	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	54.0	-	-	-	-	-	-	-	-	-	-	-	32.0	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	160.0	-	160.0	-	-	-	-	-	-	-	-	-	-	170.0	130.0	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	130.0	-	140.0	-	-	-	-	-	130.0	120.0	-	140.0	-	160.0	120.0	150.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	130.0	-	72.0	-	-	-	-	-	-	-	-	-	-	93.0	83.0	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	140.0	-	65.0	-	-	-	-	-	-	-	-	-	-	93.0	65.0	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	120.0	-	74.0	-	-	-	-	-	-	-	-	-	-	82.0	52.0	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	230.0	-	65.0	-	-	-	-	-	100.0	65.0	-	80.0	-	84.0	61.0	82.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	74	-	76	-	-	-	-	-	-	-	-	-	-	81	74	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	75	-	69	-	-	-	-	-	-	-	-	-	-	74	71	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	75	-	74	-	-	-	-	-	-	-	-	-	-	75	73	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

DRAFT

Phase I Perchlorate Treatability Study Laboratory
Analytical Results Summary

	DATE SAMPLED	2/20/98	2/21/98	2/22/98	2/23/1998; 2 h after start up	2/23/1998; 6 h after start up	2/24/98	2/25/98	2/26/98	2/27/98	2/28/98	3/1/98	3/2/98	3/3/98	3/4/98	3/5/98	3/6/98
	INFLUENT GW FLOWRATE (GPM)	25.5	-	-	25.0	25.3	25.0	25.0	24.9	25.0	-	25.5	25.3	24.5	25.8	24.8	25.0
SAMPLING PORT	ANALYTES																
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	93.0	-	-	86.0	98.0	-	98.0	-	63.0	-	73.0	-	83.0	91.0	91.0	-
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	84.0	-	-	69.0	85.0	-	100.0	-	77.0	-	51.0	-	54.0	74.0	78.0	-
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	25.0	-	-	-	-	-	-	-	-	-	-	-	-	22.0	-	-
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	5.1	-	-	-	-	-	-	-	-	-	-	-	-	9.7	-	-
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	<5	-	-	-	-	-	-	-	-	-	-	-	-	13.0	-	-
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	<5	-	-	<5	6.2	-	<5	-	<5	-	<5	-	8.0	14.0	15.0	-
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5	-	<5	-	<5	-	<5	<5	<5	-
Reactor Influent (C)	Alcohols, Methanol (mg/l)	<5	-	-	<5	<5	-	<5	-	<5	-	<5	-	<5	<5	<5	-
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	<5	-	-	<5	<5	-	<5	-	<5	-	<5	-	<5	<5	<5	-
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	<5	-	6.8	-	<5	5.1	<5	-
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	<5	-	19.0	-	<5	<5	<5	-
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	-	-	-	-	-	-	<5	-	12.0	-	<5	<5	<5	-
Air Strip. Infl. (A)	Perchlorate (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	43.0	-	-	62.0	60.0	-	31.0	-	27.0	-	38.0	-	34.0	37.0	35.0	-
Reactor Influent (C)	Perchlorate (ug/l)	36.0	-	-	62.0	49.0	-	30.0	-	29.0	-	34.0	-	40.0	29.0	35.0	-
Reactor 1/4 (D)	Perchlorate (ug/l)	13.0	-	-	-	-	-	-	-	-	-	-	-	-	12.0	-	-
Reactor 1/2 (E)	Perchlorate (ug/l)	<4	-	-	-	-	-	-	-	-	-	-	-	-	5.6	-	-
Reactor 3/4 (F)	Perchlorate (ug/l)	6.6	-	-	-	-	-	-	-	-	-	-	-	-	13.0	-	-
Reactor Effluent (G)	Perchlorate (ug/l)	<4	-	-	<4	5.5	-	<4	-	<4	-	<4	-	6.7	8.3	7.2	-
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	100.0	-	-	-	-	-	-	-	-	-	-	-	-	99.0	-	-
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	120.0	-	-	-	-	-	-	-	-	-	-	-	-	110.0	-	-
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	160.0	-	-	-	-	-	-	-	-	-	-	-	-	160.0	-	-
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	11.0	-	-	-	-	-	-	-	-	-	-	-	-	9.0	-	-
Reactor Influent (C)	Chloride (mg/l)	8.2	-	-	-	-	-	-	-	-	-	-	-	-	11.0	-	-
Reactor 1/4 (D)	Chloride (mg/l)	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	15.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	9.0	-	-	-	-	-	-	-	-	-	-	-	-	8.0	-	-
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	0.14	-	-	0.11	0.17	-	0.11	-	0.10	-	0.10	-	-	0.10	-	-
Reactor Influent (C)	Total Phosphorus (mg/l)	0.36	-	-	0.47	0.50	-	0.74	-	0.66	-	0.57	-	-	0.60	-	-
Reactor Effluent (G)	Total Phosphorus (mg/l)	0.20	-	-	0.26	0.28	-	0.40	-	0.48	-	0.44	-	-	0.49	-	-
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	<0.1	-	-
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	0.40	-	-	0.40	0.38	-	0.86	-	0.69	-	0.73	-	-	0.55	-	-
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	0.19	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	0.22	-	-	0.22	0.18	-	1.30	-	3.70	-	-	-	-	2.00	-	-
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	13.00	-	-	13.00	13.00	-	13.00	-	14.00	-	15.00	-	16.00	16.00	14.00	-
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	11.00	-	-	12.00	11.00	-	11.00	-	23.00	-	13.00	-	13.00	14.00	13.00	-
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	2.10	-	-
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	-	-
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	-	-
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	<0.1	-	-	<0.1	<0.1	-	<0.1	-	<0.1	-	<0.1	-	<0.1	0.25	0.20	-
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	<0.03	-	-	<0.03	<0.03	-	<0.03	-	<0.03	-	<0.03	-	<0.03	<0.03	<0.03	-
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	<0.03	-	-	<0.03	<0.03	-	<0.03	-	<0.03	-	0.11	-	0.12	0.10	0.08	-
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	0.58	-	-
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	<0.03	-	-
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	<0.03	-	-	-	-	-	-	-	-	-	-	-	-	0.26	-	-
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	<0.03	-	-	<0.03	<0.03	-	<0.03	-	<0.03	-	<0.03	-	0.41	0.30	0.36	-
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	16/<1	-	-	-	-	-	-	-	-	-	-	-	-	16/<1	-	-
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	15/<1	-	-	-	-	-	-	-	-	-	-	-	-	14/<1	-	-
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	14/<1	-	-	-	-	-	-	-	-	-	-	-	-	11/<1	-	-
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	0	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	ND	-	-	-	0	-	0	-	-	-	0	-	-	0	-	-
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0	-	-
Reactor Influent (C)	Coliform (MPN/100ml)	>200.5	-	-	-	-	-	-	-	-	-	-	-	-	109.1	-	-
Reactor Effluent (G)	Coliform (MPN/100ml)	>200.5	-	-	-	>200.5	-	>200.5	-	-	-	>200.5	-	-	165.2	-	-
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	3185	-	-	-	-	-	-	-	-	-	-	-	-	138@.1	-	-
Reactor Influent (C)	Bacteria (CFU/ml)	7056	-	-	-	-	-	-	-	-	-	-	-	-	211@.1	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	1540	-	-	-	211@.1	-	211@.1	-	-	-	-	-	-	217@.1	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	290.0	-	-	-	-	-	-	-	-	-	-	-	-	280.0	-	-
Reactor Influent (C)	Total Dissolved Solids (mg/l)	290.0	-	-	-	-	-	-	-	-	-	-	-	-	270.0	-	-
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	270.0	-	-	-	-	-	-	-	-	-	-	-	-	260.0	-	-
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	<5	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor Influent (C)	Total Suspended Solids (mg/l)	<5	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Reactor Effluent (G)	Total Suspended Solids (mg/l)	6.3	-	-	-	-	-	-	-	-	-	-	-	-	<5	-	-
Air Strip. Infl. (A)	Turbidity (NTU)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	<1	-	-	-	-	-	-	-	-	-	-	-	-	<1	-	-
Reactor Influent (C)	Turbidity (NTU)	4.2	-	-	-	-	-	-	-	-	-	-	-	-	<1	-	-
Reactor Effluent (G)	Turbidity (NTU)	34.0	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	100.0	-	-	-	-	-	-	-	-	-	-	-	-	84.0	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	57.0	-	-	-	-	-	-	-	-	-	-	-	-	96.0	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	120.0	-	-	-	-	-	-	-	-	-	-	-	-	23.0	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	140.0	-	-	-	-	-	-	-	-	-	-	-	-	95.0	-	-
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	140.0	-	-	140.0	140.0	-	130.0	-	110.0	-	78.0	-	-	89.0	-	-
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	87.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	74.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	72.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	72.0	-	-	93.0	78.0	-	76.0	-	52.0	-	28.0	-	-	36.0	-	-
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

DRAFT

	DATE SAMPLED	3/7/98	3/8/98	3/9/98	3/10/98	3/11/98	3/12/98	3/13/98
	INFLUENT GW FLOWRATE (GPM)	-	26.1	26.6	25.5	25.0	25.4	25.0
SAMPLING PORT	ANALYTES							
AS Effluent post-ethanol (BS-C)	Alcohols, Ethanol (mg/l)	-	-	76.0	-	110.0	120.0	160.0
Reactor Influent (C)	Alcohols, Ethanol (mg/l)	-	-	33.0	-	120.0	120.0	100.0
Reactor 1/4 (D)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	39.0
Reactor 1/2 (E)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	25.0
Reactor 3/4 (F)	Alcohols, Ethanol (mg/l)	-	-	-	-	-	-	24.0
Reactor Effluent (G)	Alcohols, Ethanol (mg/l)	-	-	18.0	-	40.0	36.0	21.0
AS Effluent post-ethanol (BS-C)	Alcohols, Methanol (mg/l)	-	-	<5	-	7.4	<5	6.9
Reactor Influent (C)	Alcohols, Methanol (mg/l)	-	-	<5	-	<5	<5	<5
Reactor 1/4 (D)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5
Reactor 1/2 (E)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5
Reactor 3/4 (F)	Alcohols, Methanol (mg/l)	-	-	-	-	-	-	<5
Reactor Effluent (G)	Alcohols, Methanol (mg/l)	-	-	<5	-	<5	5.0	<5
AS Effluent post-ethanol (BS-C)	Isopropyl alcohol mg/l	-	-	<5	-	7.2	7.4	8.3
Reactor Influent (C)	Isopropyl alcohol mg/l	-	-	<5	-	8.1	7.7	7.8
Reactor 1/4 (D)	Isopropyl alcohol mg/l	-	-	-	-	-	-	9.0
Reactor 1/2 (E)	Isopropyl alcohol mg/l	-	-	-	-	-	-	9.1
Reactor 3/4 (F)	Isopropyl alcohol mg/l	-	-	-	-	-	-	8.3
Reactor Effluent (G)	Isopropyl alcohol mg/l	-	-	<5	-	10.0	9.4	8.3
Air Strip. Infl. (A)	*Perchlorate (ug/l)*	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Perchlorate (ug/l)	-	-	46.0	-	52.0	48.0	43.0
Reactor Influent (C)	Perchlorate (ug/l)	-	-	35.0	-	40.0	40.0	40.0
Reactor 1/4 (D)	Perchlorate (ug/l)	-	-	-	-	-	-	22.0
Reactor 1/2 (E)	Perchlorate (ug/l)	-	-	-	-	-	-	7.9
Reactor 3/4 (F)	Perchlorate (ug/l)	-	-	-	-	-	-	16.0
Reactor Effluent (G)	Perchlorate (ug/l)	-	-	9.4	-	9.8	12.0	13.0
Air Strip. Infl. (A)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Reactor Influent (C)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Reactor 1/4 (D)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	Chlorate, Chlorite (mg/l)	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	110.0
Reactor Influent (C)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	110.0
Reactor Effluent (G)	Alkalinity as CaCO3 (mg/l)	-	-	-	-	-	-	170.0
Air Strip. Infl. (A)	Chloride (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloride (mg/l)	-	-	-	-	-	-	8.8
Reactor Influent (C)	Chloride (mg/l)	-	-	-	-	-	-	6.8
Reactor 1/4 (D)	Chloride (mg/l)	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chloride (mg/l)	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chloride (mg/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloride (mg/l)	-	-	-	-	-	-	9.0
Air Strip. Infl. (A)	Total Phosphorus (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	0.08
Reactor Influent (C)	Total Phosphorus (mg/l)	-	-	-	-	-	-	0.64
Reactor Effluent (G)	Total Phosphorus (mg/l)	-	-	-	-	-	-	0.41
Air Strip. Infl. (A)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	<0.1
Reactor Influent (C)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	0.69
Reactor 1/4 (D)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-
Reactor 1/2 (E)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-
Reactor 3/4 (F)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	Ammonia Nitrogen (mg/l)	-	-	-	-	-	-	1.10
Air Strip. Infl. (A)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrate Nitrogen (mg/l)	-	-	16.00	-	16.00	16.00	16.00
Reactor Influent (C)	Nitrate Nitrogen (mg/l)	-	-	12.00	-	13.00	13.00	13.00
Reactor 1/4 (D)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	0.65
Reactor 1/2 (E)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	<0.1
Reactor 3/4 (F)	Nitrate Nitrogen (mg/l)	-	-	-	-	-	-	<0.1
Reactor Effluent (G)	Nitrate Nitrogen (mg/l)	-	-	0.14	-	<0.1	<0.1	<0.1
Air Strip. Infl. (A)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Nitrite Nitrogen (mg/l)	-	-	<0.03	-	<0.03	<0.03	<0.03
Reactor Influent (C)	Nitrite Nitrogen (mg/l)	-	-	0.07	-	0.05	0.05	0.06
Reactor 1/4 (D)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	0.36
Reactor 1/2 (E)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	<0.03
Reactor 3/4 (F)	Nitrite Nitrogen (mg/l)	-	-	-	-	-	-	<0.03
Reactor Effluent (G)	Nitrite Nitrogen (mg/l)	-	-	0.24	-	0.07	<0.03	<0.03
Air Strip. Infl. (A)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	14/<1
Reactor Influent (C)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	13/<1
Reactor Effluent (G)	Sulfate, Sulfide (mg/l)	-	-	-	-	-	-	9.7/<1
Air Strip. Infl. (A)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0
Reactor Influent (C)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0
Reactor Effluent (G)	Fecal Coliform (MPN/100ml)	-	-	-	-	-	-	0
Air Strip. Infl. (A)	Coliform (MPN/100ml)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Coliform (MPN/100ml)	-	-	-	-	-	-	0.0
Reactor Influent (C)	Coliform (MPN/100ml)	-	-	-	-	-	-	73.8
Reactor Effluent (G)	Coliform (MPN/100ml)	-	-	-	-	-	-	118.4
Air Strip. Infl. (A)	Bacteria (CFU/ml)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Bacteria (CFU/ml)	-	-	-	-	-	-	8931
Reactor Influent (C)	Bacteria (CFU/ml)	-	-	-	-	-	-	-
Reactor Effluent (G)	Bacteria (CFU/ml)	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	290.0
Reactor Influent (C)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	290.0
Reactor Effluent (G)	Total Dissolved Solids (mg/l)	-	-	-	-	-	-	270.0
Air Strip. Infl. (A)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5
Reactor Influent (C)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5
Reactor Effluent (G)	Total Suspended Solids (mg/l)	-	-	-	-	-	-	<5
Air Strip. Infl. (A)	*Turbidity (NTU)*	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Turbidity (NTU)	-	-	-	-	-	-	<1
Reactor Influent (C)	Turbidity (NTU)	-	-	-	-	-	-	1.3
Reactor Effluent (G)	Turbidity (NTU)	-	-	-	-	-	-	2.1
Air Strip. Infl. (A)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Reactor Influent (C)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	Biochemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	110.0
Reactor Influent (C)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	95.0
Reactor 1/4 (D)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Reactor 1/2 (E)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Reactor 3/4 (F)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	Chemical Oxygen Demand (mg/l)	-	-	-	-	-	-	38.0
Air Strip. Infl. (A)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-
Reactor Influent (C)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-
Reactor Effluent (G)	N-Nitrosodimethylamine (NDMA) (ug/l)	-	-	-	-	-	-	-

ug/l = microgram per liter, mg/l = milligram per liter
GW = groundwater, VOC = volatile organic compound
Ba = Barium, V = Vanadium, Zn = Zinc, Mg = Magnesium
Na = Sodium, K = Potassium
MPN/ml = most probable number per milliliter
CFU/ml = colony forming units per milliliter
NTU = nephelometric turbidity units

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Phase I Perchlorate Treatability Study
VOC Analytical Results Summary

SAMPLING PORT	DATE SAMPLED	11/5/97	11/7/97	11/17/97	12/16/97	12/17/97	12/18/97	12/19/97	12/24/97	12/31/97	1/28/98	2/4/98
	INFLUENT GW FLOWRATE (GPM)	-	5.1	4.0	29.4	30.0	29.4	28.3	25.1	20.3	25.0	26.4
SAMPLING PORT	ANALYTES											
Air Strip. Infl. (A)	Acetone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	3600.0	<100
Reactor Influent (C)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	2000.0	<100
Reactor Effluent (G)	Acetone (ug/l)	-	-	-	-	-	-	-	-	-	6700.0	310.0
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	<100	<5
Reactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	<50	<5
Reactor Effluent (G)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	63.0	<5
Air Strip. Infl. (A)	4-Methyl-2-pentanone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	880.0	210.0
Reactor Influent (C)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	810.0	200.0
Reactor Effluent (G)	4-Methyl-2-pentanone (ug/l)	-	-	-	-	-	-	-	-	-	<250	87.0
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 8260	6.3	6.3	-	6.6	-	-	6.3	6.9	8.0	-	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethene (ug/l)	-	<5	-	<5	-	-	<5	<5	<5	9.2	8.2
Reactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	7.8	6.2
Reactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	<5	-	-	-	-	-	-	<5	<5
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	<100	<5
Reactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	<50	<5
Reactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	110.0	<5
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 8260	120	110	-	120.0	-	-	120.0	130.0	150.0	-	-
AS Effluent post-ethanol (BS-C)	Trichloroethene (ug/l)	-	<5	-	36.0	-	-	41.0	53.0	18.0	140.0	120.0
Reactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	120.0	99.0
Reactor Effluent (G)	Trichloroethene (ug/l)	-	-	<5	-	-	-	-	-	-	<5	19.0
Air Strip. Infl. (A)	Ethanol (mg/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Ethanol (mg/l)	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Vinyl chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Influent (C)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Effluent (G)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1
Air Strip. Infl. (A)	Trichlorofluoromethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	10.00
Reactor Influent (C)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	7.80
Reactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	3.00
Air Strip. Infl. (A)	Methylene chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Influent (C)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.18
Reactor Effluent (G)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.17
Air Strip. Infl. (A)	1,1-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.50
Reactor Influent (C)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.50
Reactor Effluent (G)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.20
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	2.40
Reactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	2.10
Reactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	1.10
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80
Reactor Influent (C)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80
Reactor Effluent (G)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	-	1.60
Air Strip. Infl. (A)	1,1,1-Trichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Influent (C)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Reactor Effluent (G)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Carbon tetrachloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	2.10
Reactor Influent (C)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80
Reactor Effluent (G)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	-	0.34
Air Strip. Infl. (A)	1,2-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.90
Reactor Influent (C)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.80
Reactor Effluent (G)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	-	1.20
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	150.00
Reactor Influent (C)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	140.00
Reactor Effluent (G)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	28.00
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	0.26
Reactor Influent (C)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	0.20
Reactor Effluent (G)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	-	<0.1
Air Strip. Infl. (A)	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
Air Strip. Eff. (B)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	<0.1
Reactor Influent (C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	0.16
Reactor Effluent (G)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	<0.1

ug/L = micrograms per liter, mg/L = milligrams per liter

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Phase I Perchlorate Treatability Study
VOC Analytical Results Summary

SAMPLING PORT	DATE SAMPLED	2/5/98	2/6/98	2/17/98	2/18/98	2/19/98	2/20/98	2/27/98	3/4/98	3/5/98	3/6/98	3/13/98
	INFLUENT GW FLOWRATE (GPM)	25.1	24.9	25.2	25.6	25.1	26.1	25.0	24.8	24.8	25.0	27.0
	ANALYTES											
Air Strip. Infl. (A)	Acetone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Acetone (ug/l)	-	<100	<100	<100	-	-	-	-	-	-	-
Reactor Influent (C)	Acetone (ug/l)	-	340.0	220.0	260.0	-	-	-	-	-	-	-
Reactor Effluent (G)	Acetone (ug/l)	-	330.0	560.0	530.0	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Chloroform (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Reactor Influent (C)	Chloroform (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Reactor Effluent (G)	Chloroform (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Air Strip. Infl. (A)	4-Methyl-2-pentanone (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	4-Methyl-2-pentanone (ug/l)	-	220.0	720.0	550.0	-	-	-	-	-	-	-
Reactor Influent (C)	4-Methyl-2-pentanone (ug/l)	-	220.0	640.0	540.0	-	-	-	-	-	-	-
Reactor Effluent (G)	4-Methyl-2-pentanone (ug/l)	-	95.0	280.0	260.0	-	-	-	-	-	-	-
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethene (ug/l)	-	7.5	9.0	7.4	-	-	-	-	-	-	-
Reactor Influent (C)	1,1-Dichloroethene (ug/l)	-	6.3	7.5	8.1	-	-	-	-	-	-	-
Reactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Tetrachloroethene (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Reactor Influent (C)	Tetrachloroethene (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Reactor Effluent (G)	Tetrachloroethene (ug/l)	-	<5	<5	<5	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 8260	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Trichloroethene (ug/l)	-	120.0	150.0	140.0	-	-	-	-	-	-	-
Reactor Influent (C)	Trichloroethene (ug/l)	-	110.0	130.0	130.0	-	-	-	-	-	-	-
Reactor Effluent (G)	Trichloroethene (ug/l)	-	22.0	33.0	33.0	-	-	-	-	-	-	-
Air Strip. Infl. (A)	Ethanol (mg/l) EPA 502.2	-	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ethanol (mg/l)	-	-	96.0	-	-	93.0	-	-	-	-	160.0
Reactor Influent (C)	Ethanol (mg/l)	-	-	100.0	-	-	84.0	-	-	-	-	100.0
Reactor Effluent (G)	Ethanol (mg/l)	-	-	6.2	-	-	<5	-	14.0	-	-	21.0
Air Strip. Infl. (A)	Vinyl chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	<0.1	-
Air Strip. Eff. (B)	Vinyl chloride (ug/l)	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	Vinyl chloride (ug/l)	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	<0.1
Reactor Influent (C)	Vinyl chloride (ug/l)	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	<0.1
Reactor Effluent (G)	Vinyl chloride (ug/l)	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	<0.1
Air Strip. Infl. (A)	Trichlorofluoromethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	0.22	-
Air Strip. Eff. (B)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	0.18	-	-	-	<0.1
Reactor Influent (C)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	0.19	-	-	-	<0.1
Reactor Effluent (G)	Trichlorofluoromethane (ug/l)	-	-	-	-	-	-	<0.1	<0.1	-	-	<0.1
Air Strip. Infl. (A)	1,1-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	11.00	-
Air Strip. Eff. (B)	1,1-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	0.56	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethene (ug/l)	-	12.00	8.50	12.00	-	10.00	10.00	-	-	-	12.00
Reactor Influent (C)	1,1-Dichloroethene (ug/l)	-	9.90	6.60	11.00	-	11.00	10.00	-	-	-	11.00
Reactor Effluent (G)	1,1-Dichloroethene (ug/l)	-	4.00	6.30	6.20	-	5.90	6.60	8.90	-	-	8.40
Air Strip. Infl. (A)	Methylene chloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	<0.1	-
Air Strip. Eff. (B)	Methylene chloride (ug/l)	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	Methylene chloride (ug/l)	-	0.25	<0.1	0.14	-	<0.1	<0.1	-	-	-	<0.1
Reactor Influent (C)	Methylene chloride (ug/l)	-	0.12	<0.1	<0.1	-	0.29	<0.1	-	-	-	0.11
Reactor Effluent (G)	Methylene chloride (ug/l)	-	0.25	0.29	0.25	-	0.47	0.32	0.32	-	-	0.18
Air Strip. Infl. (A)	1,1-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	1.60	-
Air Strip. Eff. (B)	1,1-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	0.13	-
AS Effluent post-ethanol (BS-C)	1,1-Dichloroethane (ug/l)	-	1.60	1.50	1.50	-	1.50	1.40	-	-	-	1.10
Reactor Influent (C)	1,1-Dichloroethane (ug/l)	-	1.60	1.60	1.50	-	1.50	1.50	-	-	-	1.20
Reactor Effluent (G)	1,1-Dichloroethane (ug/l)	-	1.10	1.50	1.40	-	1.50	1.40	1.50	-	-	1.10
Air Strip. Infl. (A)	cis-1,2-Dichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	2.70	-
Air Strip. Eff. (B)	cis-1,2-Dichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	0.30	-
AS Effluent post-ethanol (BS-C)	cis-1,2-Dichloroethene (ug/l)	-	2.70	2.70	2.60	-	2.60	2.40	-	-	-	2.80
Reactor Influent (C)	cis-1,2-Dichloroethene (ug/l)	-	2.50	2.70	2.60	-	2.50	2.50	-	-	-	2.70
Reactor Effluent (G)	cis-1,2-Dichloroethene (ug/l)	-	1.10	1.80	1.70	-	1.80	1.80	2.00	-	-	2.20
Air Strip. Infl. (A)	Chloroform (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	2.00	-
Air Strip. Eff. (B)	Chloroform (ug/l)	-	-	-	-	-	-	-	-	-	0.24	-
AS Effluent post-ethanol (BS-C)	Chloroform (ug/l)	-	1.90	2.00	2.00	-	1.90	1.80	-	-	-	2.00
Reactor Influent (C)	Chloroform (ug/l)	-	2.00	2.10	2.00	-	2.00	2.00	-	-	-	2.10
Reactor Effluent (G)	Chloroform (ug/l)	-	1.70	2.40	2.30	-	2.30	2.20	2.10	-	-	2.20
Air Strip. Infl. (A)	1,1,1-Trichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	<0.1	-
Air Strip. Eff. (B)	1,1,1-Trichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	1,1,1-Trichloroethane (ug/l)	-	-	0.12	0.12	-	0.12	0.10	-	-	-	0.14
Reactor Influent (C)	1,1,1-Trichloroethane (ug/l)	-	-	0.14	<0.1	-	0.11	<0.1	-	-	-	0.16
Reactor Effluent (G)	1,1,1-Trichloroethane (ug/l)	-	-	<0.1	<0.1	-	<0.1	<0.1	<0.1	-	-	<0.1
Air Strip. Infl. (A)	Carbon tetrachloride (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	1.20	-
Air Strip. Eff. (B)	Carbon tetrachloride (ug/l)	-	-	-	-	-	-	-	-	-	0.23	-
AS Effluent post-ethanol (BS-C)	Carbon tetrachloride (ug/l)	-	2.20	2.40	2.20	-	2.30	2.00	-	-	-	1.60
Reactor Influent (C)	Carbon tetrachloride (ug/l)	-	2.00	2.10	2.00	-	2.00	2.00	-	-	-	1.50
Reactor Effluent (G)	Carbon tetrachloride (ug/l)	-	0.30	0.30	0.32	-	0.29	0.29	0.83	-	-	0.29
Air Strip. Infl. (A)	1,2-Dichloroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	1.70	-
Air Strip. Eff. (B)	1,2-Dichloroethane (ug/l)	-	-	-	-	-	-	-	-	-	0.33	-
AS Effluent post-ethanol (BS-C)	1,2-Dichloroethane (ug/l)	-	2.30	2.00	2.10	-	1.70	1.60	-	-	-	1.50
Reactor Influent (C)	1,2-Dichloroethane (ug/l)	-	2.30	2.30	2.20	-	1.70	1.70	-	-	-	1.40
Reactor Effluent (G)	1,2-Dichloroethane (ug/l)	-	1.40	1.80	1.50	-	1.40	1.30	1.20	-	-	1.10
Air Strip. Infl. (A)	Trichloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	210.00	-
Air Strip. Eff. (B)	Trichloroethene (ug/l)	-	-	-	-	-	-	-	-	-	19.00	-
AS Effluent post-ethanol (BS-C)	Trichloroethene (ug/l)	-	230.00	190.00	190.00	-	160.00	160.00	-	-	-	180.00
Reactor Influent (C)	Trichloroethene (ug/l)	-	190.00	160.00	170.00	-	140.00	160.00	-	-	-	-
Reactor Effluent (G)	Trichloroethene (ug/l)	-	33.00	45.00	45.00	-	38.00	45.00	53.00	-	-	-
Air Strip. Infl. (A)	Tetrachloroethene (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	0.18	-
Air Strip. Eff. (B)	Tetrachloroethene (ug/l)	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	Tetrachloroethene (ug/l)	-	0.46	0.17	0.17	-	0.15	0.19	-	-	-	0.21
Reactor Influent (C)	Tetrachloroethene (ug/l)	-	0.35	0.15	0.16	-	0.13	0.20	-	-	-	0.15
Reactor Effluent (G)	Tetrachloroethene (ug/l)	-	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	-	-	<0.1
Air Strip. Infl. (A)	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/l) EPA 502.2	-	-	-	-	-	-	-	-	-	0.14	-
Air Strip. Eff. (B)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	<0.1	-
AS Effluent post-ethanol (BS-C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	0.20	<0.1	<0.1	-	<0.1	0.11	-	-	-	0.25
Reactor Influent (C)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	<0.1	<0.1	<0.1	-	<0.1	<0.1	-	-	-	0.18
Reactor Effluent (G)	1,1,2-Trichloro-1,2,2-trifluoroethane	-	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	-	-	<0.1

ug/L = micrograms per liter, mg/L = milligrams per liter

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Phase I Perchlorate Treatability Study
Title 22 Metals, K, NA, Mg, Fe, Ca, Mn Analytical Results Summary Table

	DATE SAMPLED	11/5/97	1/29/98	2/4/98	2/5/98	2/6/98	2/17/98	2/18/98	2/19/98	2/20/98	3/4/98	3/13/98
Sampling Port	Flowrate	-	25.0	26.4	25.1	24.9	25.2	25.6	25.1	25.5	25.8	25.0
Air Strip. Infl. (A)	Ba (ug/L)	23	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ba (ug/L)	-	27	29	-	24	28	26	-	24	24	26
Reactor Influent (C)	Ba (ug/L)	-	26	26	-	24	25	25	-	24	22	25
Reactor Effluent (G)	Ba (ug/L)	-	26	26	-	22	24	25	-	20	22	28
Air Strip. Infl. (A)	Ca (ug/L)	18000	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Ca (ug/L)	-	20000	21000	-	19000	19000	18000	-	19000	19000	21000
Reactor Influent (C)	Ca (ug/L)	-	20000	21000	-	19000	19000	18000	-	20000	18000	21000
Reactor Effluent (G)	Ca (ug/L)	-	20000	21000	-	19000	19000	18000	-	17000	18000	20000
AS Effluent post-ethanol (BS-C)	Fe (ug/L)	-	-	-	-	-	-	-	-	450	<100	<100
Reactor Influent (C)	Fe (ug/L)	-	-	-	-	-	-	-	-	<100	<100	<100
Reactor Effluent (G)	Fe (ug/L)	-	-	-	-	-	-	-	TEQUILA	<100	<100	<100
AS Effluent post-ethanol (BS-C)	Hg (ug/L)	-	-	-	-	0.39	<0.2	<0.2	-	<0.2	<0.2	<0.2
Reactor Influent (C)	Hg (ug/L)	-	-	-	-	0.37	>0.2	<0.2	-	<0.2	<0.2	<0.2
Reactor Effluent (G)	Hg (ug/L)	-	-	-	-	0.38	<0.2	<0.2	-	<0.2	<0.2	<0.2
Air Strip. Infl. (A)	K (ug/L)	1200	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	K (ug/L)	-	1500	1500	-	1300	1400	1300	-	1300	1400	1400
Reactor Influent (C)	K (ug/L)	-	1400	1300	-	1200	1500	1300	-	1200	1300	1400
Reactor Effluent (G)	K (ug/L)	-	1300	1100	-	1100	1200	1300	-	<1000	1200	1300
Air Strip. Infl. (A)	Mg (ug/L)	11000	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Mg (ug/L)	-	13000	13000	-	12000	12000	12000	-	11000	12000	12000
Reactor Influent (C)	Mg (ug/L)	-	12000	13000	-	12000	12000	12000	-	12000	11000	12000
Reactor Effluent (G)	Mg (ug/L)	-	13000	12000	-	11000	12000	12000	-	10000	11000	12000
Air Strip. Infl. (A)	Na (ug/L)	30000	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Na (ug/L)	-	36000	36000	-	34000	35000	33000	-	34000	34000	35000
Reactor Influent (C)	Na (ug/L)	-	35000	36000	-	34000	33000	33000	-	34000	32000	34000
Reactor Effluent (G)	Na (ug/L)	-	36000	36000	-	33000	34000	33000	-	30000	33000	33000
Air Strip. Infl. (A)	V (ug/L)	14	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	V (ug/L)	-	<20	20	-	<20	<20	<20	-	<20	<20	<20
Reactor Influent (C)	V (ug/L)	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20
Reactor Effluent (G)	V (ug/L)	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20
Air Strip. Infl. (A)	Zn (ug/L)	35	-	-	-	-	-	-	-	-	-	-
AS Effluent post-ethanol (BS-C)	Zn (ug/L)	-	<20	<20	-	<20	22	<20	-	<20	55	<20
Reactor Influent (C)	Zn (ug/L)	-	<20	<20	-	<20	48	<20	-	<20	<20	<20
Reactor Effluent (G)	Zn (ug/L)	-	<20	<20	-	<20	<20	<20	-	<20	<20	<20

ug/l = microgram per liter, GW = groundwater
Ba = Barium, Ca = Calcium, Fe = Iron, Hg = Mercury, K = Potassium, Mg = Magnesium, Na = Sodium, V = Vanadium, Zn = Zinc

APPENDIX E

FIELD DATA, DO PROFILE SUMMARY

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Summary of Collected Operational Data

Date	Flowrate AS-Effl (gpm)	Flowrate Reactor (gpm)	pH AS-Infl (A)	pH AS-Effl (BS-C)	pH R-Infl (C)	pH R-25% (D)	pH R-50% (E)	pH R-75% (F)	pH R-Effl (G)
7-Nov	5.1	30.1	-	-	8.38	-	-	-	7.15
8-Nov	3.9	30.1	-	-	8.22	-	-	-	8.34
9-Nov	3.8	29.7	-	-	8.43	-	-	-	8.39
10-Nov	3.6	29.5	-	-	8.34	-	-	-	7.93
11-Nov	3.5	30.1	-	-	8.76	-	-	-	8.70
12-Nov	4.1	30.6	-	-	8.55	-	-	-	8.62
13-Nov	3.8	30.0	-	-	8.50	-	-	-	7.17
14-Nov	4.0	30.0	-	-	8.92	-	-	-	8.90
15-Nov	3.8	29.9	-	-	-	-	-	-	8.00
16-Nov	3.9	30.1	-	-	-	-	-	-	7.48
17-Nov	4.0	29.9	-	-	8.67	-	-	-	8.81
18-Nov	4.3	27.0	-	-	8.35	-	-	-	8.41
19-Nov	4.4	29.6	-	-	8.36	-	-	-	8.36
20-Nov	10.1	29.5	-	-	-	-	-	-	8.07
21-Nov	9.8	30.7	-	-	-	-	-	-	8.21
22-Nov	-	-	-	-	-	-	-	-	-
23-Nov	-	-	-	-	-	-	-	-	-
24-Nov	10.9	30.8	-	-	8.21	-	-	-	8.27
25-Nov	10.6	30.5	-	-	7.99	-	-	-	8.07
26-Nov	15.2	30.2	-	-	8.45	-	-	-	8.61
27-Nov	-	-	-	-	-	-	-	-	-
28-Nov	20.1	31.1	-	-	8.34	-	-	-	8.46
29-Nov	-	-	-	-	-	-	-	-	-
30-Nov	20.2	31.3	-	-	8.46	-	-	-	8.61
1-Dec	20.7	30.8	-	-	8.38	-	-	-	8.53
2-Dec	19.6	25.0	-	-	8.10	-	-	-	8.29
3-Dec	-	-	-	-	-	-	-	-	-
4-Dec	-	-	-	-	-	-	-	-	-
5-Dec	20.5	29.9	-	-	8.20	-	-	-	8.09
6-Dec	20.0	30.2	-	-	8.30	-	-	-	8.05
7-Dec	5.0	29.3	-	-	-	-	-	-	-
8-Dec	10.3	29.8	-	-	7.83	-	-	-	7.72
9-Dec	10.0	31.0	-	-	8.00	-	-	-	8.08
10-Dec	10.0	30.3	-	-	7.29	-	-	-	7.00
11-Dec	29.9	30.8	-	-	7.96	-	-	-	7.64
12-Dec	29.9	31.0	-	-	7.67	-	-	-	7.87
13-Dec	29.4	30.4	-	-	7.49	-	-	-	7.56
14-Dec	29.6	30.4	-	-	7.60	-	-	-	8.17
15-Dec	29.0	30.2	-	-	8.22	-	-	-	8.58
16-Dec	29.4	30.0	-	-	7.91	-	-	-	8.36
17-Dec	30.0	31.0	-	-	7.75	-	-	-	8.19
18-Dec	29.4	29.7	-	-	7.28	-	-	-	7.72
19-Dec	28.3	28.9	-	-	7.82	-	-	-	7.99
20-Dec	28.6	29.6	-	-	-	-	-	-	-
21-Dec	28.9	29.2	-	-	-	-	-	-	7.77
22-Dec	29.0	29.5	-	-	7.75	-	-	-	7.91
23-Dec	29.1	29.4	-	-	7.60	-	-	-	7.47
24-Dec	25.1	30.3	-	-	7.65	-	-	-	7.74
25-Dec	-	-	-	-	-	-	-	-	-
26-Dec	24.0	30.1	-	-	7.87	-	-	-	8.00
27-Dec	-	-	-	-	-	-	-	-	-
28-Dec	20.0	30.0	-	-	-	-	-	-	-
29-Dec	20.1	30.0	-	-	7.72	-	-	-	7.94
30-Dec	20.6	29.9	-	-	7.64	-	-	-	7.99
31-Dec	20.3	30.0	-	-	8.13	-	-	-	8.26
1-Jan	-	-	-	-	-	-	-	-	-
2-Jan	19.5	28.8	-	-	8.03	-	-	-	8.24
3-Jan	20.7	28.8	-	-	8.00	-	-	-	8.16
4-Jan	-	-	-	-	-	-	-	-	-
5-Jan	19.5	28.9	7.31	8.17	8.05	-	-	-	8.54
6-Jan	20.0	29.5	7.26	8.13	8.25	-	-	-	8.49
7-Jan	20.8	29.5	7.14	8.01	8.12	-	-	-	8.51
8-Jan	20.1	30.0	6.88	7.75	8.04	-	-	-	8.25
9-Jan	20.0	30.0	6.88	7.73	7.97	-	-	-	8.18
10-Jan	20.0	30.1	7.00	7.84	8.09	-	-	-	8.28
11-Jan	19.0	30.0	-	-	8.20	-	-	-	8.48
12-Jan	19.2	29.3	-	-	8.10	-	-	-	8.09
13-Jan	19.5	29.8	7.01	7.80	7.95	-	-	-	8.21
14-Jan	19.2	29.8	7.12	7.92	8.07	-	-	-	8.33
15-Jan	19.8	30.0	7.16	7.88	7.96	-	-	-	8.30
16-Jan	20.0	30.5	7.22	7.94	8.09	-	-	-	8.34
17-Jan	-	-	-	-	-	-	-	-	-
18-Jan	20.1	29.2	-	-	8.15	-	-	-	8.29
19-Jan	19.5	27.5	7.21	7.98	8.01	-	-	-	8.21
20-Jan	19.5	29.0	7.16	7.82	7.80	-	-	-	7.87
21-Jan	20.0	29.0	6.97	7.76	7.77	-	-	-	7.82
22-Jan	-	-	-	-	-	-	-	-	-
23-Jan	20.6	31.0	7.14	7.26	7.42	-	-	-	7.84
24-Jan	20.2	29.4	7.10	7.11	7.31	-	-	-	7.88
25-Jan	19.8	29.5	7.17	7.25	7.40	-	-	-	8.02
26-Jan	20.0	30.0	7.17	7.16	7.36	-	-	-	7.97
27-Jan	20.0	30.5	7.19	7.20	7.38	-	-	-	7.83
28-Jan	25.0	29.9	-	7.11	7.30	-	-	-	7.83
29-Jan	25.0	29.7	-	7.17	7.22	7.80	7.7	7.76	7.81
30-Jan	25.5	30.1	-	7.13	7.27	-	-	-	8.27

Date	T AS-Infl (A) (°C)	T AS-Effl (BS-C) (°C)	T R-Infl (C) (°C)	T R-25% (D) (°C)	T R-50% (E) (°C)	T R-75% (F) (°C)	T R-Effl (G) (°C)	ORP AS-Infl (A) (mV)	ORP AS-Effl (BS-C) (mV)	ORP R-Infl (C) (mV)	ORP R-25% (D) (mV)	ORP R-50% (E) (mV)	ORP R-75% (F) (mV)	ORP R-Effl (G) (mV)
7-Nov	-	-	22.1	-	-	-	22.1	-	-	-	-	-	-	-
8-Nov	-	-	18.3	-	-	-	18.6	-	-	-	-	-	-	-
9-Nov	-	-	19.6	-	-	-	19.9	-	-	-	-	-	-	-
10-Nov	-	-	18.6	-	-	-	19.1	-	-	-	-	-	-	-
11-Nov	-	-	18.0	-	-	-	18.7	-	-	-	-	-	-	-
12-Nov	-	-	20.2	-	-	-	19.6	-	-	-	-	-	-	-
13-Nov	-	-	19.1	-	-	-	18.8	-	-	-	-	-	-	-
14-Nov	-	-	19.3	-	-	-	19.3	-	-	-	-	-	-	-
15-Nov	-	-	15.0	-	-	-	15.9	-	-	-	-	-	-	-
16-Nov	-	-	17.1	-	-	-	17.2	-	-	-	-	-	-	-
17-Nov	-	-	19.1	-	-	-	19.2	-	-	-	-	-	-	-
18-Nov	-	-	18.2	-	-	-	18.4	-	-	-	-	-	-	-
19-Nov	-	-	18.6	-	-	-	18.5	-	-	-	-	-	-	-
20-Nov	-	-	18.7	-	-	-	18.6	-	-	-	-	-	-	-
21-Nov	-	-	18.9	-	-	-	19.2	-	-	-	-	-	-	-
22-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-Nov	-	-	19.9	-	-	-	20.1	-	-	-	-	-	-	-
25-Nov	-	-	19.5	-	-	-	19.3	-	-	-	-	-	-	-
26-Nov	-	-	14.5	-	-	-	15.4	-	-	-	-	-	-	-
27-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Nov	-	-	17.7	-	-	-	17.4	-	-	-	-	-	-	-
29-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Nov	-	-	13.9	-	-	-	14.3	-	-	-	-	-	-	-
1-Dec	-	-	13.9	-	-	-	14.7	-	-	-	-	-	-	-
2-Dec	-	-	15.2	-	-	-	15.7	-	-	-	-	-	-	-
3-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Dec	-	-	15.3	-	-	-	14.4	-	-	-	-	-	-	-
6-Dec	-	-	16.6	-	-	-	16.6	-	-	-	-	-	-	-
7-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Dec	-	-	13.3	-	-	-	14.7	-	-	-	-	-	-	-
9-Dec	-	-	18.3	-	-	-	18.1	-	-	110.0	-	-	-	96.3
10-Dec	-	-	17.5	-	-	-	18.0	-	-	-41.1	-	-	-	-72.1
11-Dec	-	-	18.3	-	-	-	18.6	-	-	118.5	-	-	-	35.0
12-Dec	-	-	17.5	-	-	-	16.3	-	-	153.3	-	-	-	180.5
13-Dec	-	-	17.8	-	-	-	16.7	-	-	228.6	-	-	-	172.7
14-Dec	-	-	18.3	-	-	-	17.3	-	-	108.6	-	-	-	71.4
15-Dec	-	-	18.5	-	-	-	18.5	-	-	104.6	-	-	-	96.0
16-Dec	-	-	18.6	-	-	-	18.7	-	-	90.8	-	-	-	42.5
17-Dec	-	-	18.7	-	-	-	18.8	-	-	76.0	-	-	-	40.8
18-Dec	-	-	17.2	-	-	-	17.7	-	-	-	-	-	-	-
19-Dec	-	-	19.0	-	-	-	19.1	-	-	65.5	-	-	-	65.0
20-Dec	-	-	17.2	-	-	-	17.4	-	-	105.6	-	-	-	37.8
21-Dec	-	-	18.8	-	-	-	18.8	-	-	74.9	-	-	-	38.0
22-Dec	-	-	18.5	-	-	-	18.1	-	-	60.4	-	-	-	30.0
23-Dec	-	-	18.6	-	-	-	18.6	-	-	101.3	-	-	-	98.2
24-Dec	-	-	18.8	-	-	-	18.8	-	-	53.1	-	-	-	21.3
25-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Dec	-	-	18.7	-	-	-	18.8	-	-	92.8	-	-	-	35.0
27-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-Dec	-	-	18.5	-	-	-	19.1	-	-	100.7	-	-	-	62.3
30-Dec	-	-	19.2	-	-	-	19.4	-	-	105.5	-	-	-	63.0
31-Dec	-	-	19.3	-	-	-	19.3	-	-	-7.0	-	-	-	-22.1
1-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Jan	-	-	18.3	-	-	-	18.0	-	-	87.8	-	-	-	35.2
3-Jan	-	-	18.6	-	-	-	18.6	-	-	114.8	-	-	-	70.4
4-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Jan	18.6	18.3	18.2	-	-	-	18.4	144.5	148.7	107.0	-	-	-	32.0
6-Jan	18.6	18.2	18.1	-	-	-	18.2	118.7	130.1	-26.0	-	-	-	-94.0
7-Jan	18.1	18.4	18.3	-	-	-	18.4	138.4	120.9	43.8	-	-	-	-130.0
8-Jan	18.7	18.5	18.6	-	-	-	18.6	95.6	75.5	25.0	-	-	-	-116.6
9-Jan	18.7	18.6	18.7	-	-	-	18.7	58.0	45.0	28.0	-	-	-	-103.0
10-Jan	19.0	18.8	18.9	-	-	-	18.8	82.5	75.9	5.0	-	-	-	-180.0
11-Jan	-	-	18.9	-	-	-	18.6	-	-	49.2	-	-	-	-20.0
12-Jan	-	-	18.8	-	-	-	17.7	-	-	29.5	-	-	-	16.0
13-Jan	19.2	19.1	19.2	-	-	-	19.2	85.1	68.1	-19.0	-	-	-	-180.0
14-Jan	18.9	18.8	18.9	-	-	-	18.9	64.0	52.0	-49.0	-	-	-	-212.0
15-Jan	19.1	18.9	18.9	-	-	-	18.9	39.0	28.5	-63.0	-	-	-	-161.0
16-Jan	19.2	19.2	19.3	-	-	-	19.3	107.6	96.8	-5.0	-	-	-	-182.0
17-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-Jan	-	-	19.2	-	-	-	19.1	-	-	-107.6	-	-	-	-244.0
19-Jan	18.8	18.7	18.6	-	-	-	18.6	70.1	53.4	-100.0	-	-	-	-275.0
20-Jan	18.8	18.6	18.6	-	-	-	18.6	124.0	102.0	-97.0	-	-	-	-205.0
21-Jan	18.6	18.3	18.1	-	-	-	18.3	105.5	100.0	-93.0	-	-	-	-215.0
22-Jan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Jan	18.7	18.8	18.9	-	-	-	18.8	122.5	123.4	-125.0	-	-	-	-208.0
24-Jan	19.0	19.1	19.2	-	-	-	19.3	64.5	-5.9	-178.3	-	-	-	-225.0
25-Jan	18.7	18.7	19.0	-	-	-	19.0	-	19.7	-188.0	-	-	-	-214.0
26-Jan	18.7	19.0	19.0	-	-	-	19.0	-	129.0	-204.0	-	-	-	-239.0
27-Jan	19.3	19.3	19.4	-	-	-	19.5	134.5	126.2	-203.0	-	-	-	-235.0
28-Jan	-	19.1	19.1	-	-	-	19.1	-	21.6	-191.9	-	-	-	-263.0
29-Jan	-	19.2	19.2	18.6	18.4	18.7	19.2	-	-16.4	-208.8	-229.5	-250.7	-216.2	-274.0
30-Jan	-	18.9	18.8	-	-	-	19.0	-	25.4	-202.7	-	-	-	-281.0

Date	D.O. Well/AS Effl (BS-C) (ppm)	D.O. R-Infl -Inline (C) (ppm)	D.O. R-Infl (C) (ppm)	D.O. R-25% (D) (ppm)	D.O. R-50% (E) (ppm)	D.O. R-75% (F) (ppm)	D.O. R-Effl (G) (ppm)	D.O. R-Effl -Inline (G) (ppm)	Ethanol Flowrate (ml/min)
7-Nov	-	1.4	-	-	-	-	-	0.1	-
8-Nov	-	1.6	-	-	-	-	-	0.1	-
9-Nov	-	1.1	-	-	-	-	-	0.1	-
10-Nov	-	1.0	-	-	-	-	-	0.0	-
11-Nov	-	0.7	-	-	-	-	-	0.1	-
12-Nov	-	0.6	-	-	-	-	-	0.0	-
13-Nov	-	1.2	-	-	-	-	-	0.0	-
14-Nov	-	1.5	-	-	-	-	-	0.6	-
15-Nov	-	1.2	-	-	-	-	-	0.1	-
16-Nov	-	1.3	-	-	-	-	-	0.1	-
17-Nov	-	0.9	-	-	-	-	-	1.0	-
18-Nov	-	0.7	-	-	-	-	-	0.0	-
19-Nov	-	1.1	-	-	-	-	-	0.0	-
20-Nov	-	0.7	-	-	-	-	-	0.0	-
21-Nov	-	0.5	-	-	-	-	-	0.0	-
22-Nov	-	-	-	-	-	-	-	-	-
23-Nov	-	-	-	-	-	-	-	-	-
24-Nov	-	0.4	-	-	-	-	-	0.1	-
25-Nov	-	0.4	-	-	-	-	-	0.2	-
26-Nov	-	0.4	-	-	-	-	-	0.1	-
27-Nov	-	-	-	-	-	-	-	-	-
28-Nov	-	0.4	-	-	-	-	-	0.1	-
29-Nov	-	-	-	-	-	-	-	-	-
30-Nov	-	5.3	-	-	-	-	-	0.5	-
1-Dec	-	4.6	-	-	-	-	-	0.1	-
2-Dec	-	4.1	-	-	-	-	-	0.0	-
3-Dec	-	-	-	-	-	-	-	-	-
4-Dec	-	-	-	-	-	-	-	-	-
5-Dec	-	6.0	-	-	-	-	-	3.3	-
6-Dec	-	6.1	-	-	-	-	-	2.7	-
7-Dec	-	-	-	-	-	-	-	-	-
8-Dec	-	5.2	-	-	-	-	-	2.5	-
9-Dec	-	4.3	-	-	-	-	-	1.5	-
10-Dec	-	-	-	-	-	-	-	1.5	-
11-Dec	-	8.3	-	-	-	-	-	0.3	4.1
12-Dec	-	8.1	-	-	-	-	-	2.0	10.4
13-Dec	-	-	-	-	-	-	-	0.5	2.0
14-Dec	-	8.2	-	-	-	-	-	0.2	7.0
15-Dec	-	8.4	-	-	-	-	-	0.2	9.4
16-Dec	-	8.0	-	-	-	-	-	0.2	6.4
17-Dec	-	8.5	-	-	-	-	-	0.2	5.9
18-Dec	-	8.3	-	-	-	-	-	0.3	5.6
19-Dec	-	9.2	-	-	-	-	-	0.3	5.9
20-Dec	-	9.3	-	-	-	-	-	0.5	8.2
21-Dec	-	9.8	-	-	-	-	-	0.6	9.3
22-Dec	-	10.6	-	-	-	-	-	0.3	8.3
23-Dec	-	11.1	-	-	-	-	-	0.4	9.4
24-Dec	-	9.5	-	-	-	-	-	0.7	2.9
25-Dec	-	-	-	-	-	-	-	-	-
26-Dec	-	8.4	-	-	-	-	-	0.2	5.4
27-Dec	-	-	-	-	-	-	-	-	-
28-Dec	-	6.7	-	-	-	-	-	0.2	4.9
29-Dec	-	6.6	-	-	-	-	-	0.2	7.2
30-Dec	-	6.0	-	-	-	-	-	0.3	7.1
31-Dec	-	6.2	-	-	-	-	-	0.3	7.7
1-Jan	-	-	-	-	-	-	-	-	-
2-Jan	-	5.1	-	-	-	-	-	0.3	6.5
3-Jan	-	5.2	-	-	-	-	-	0.2	10.2
4-Jan	-	-	-	-	-	-	-	-	-
5-Jan	-	5.3	-	-	-	-	-	0.3	4.7
6-Jan	-	5.7	-	-	-	-	-	0.3	5.3
7-Jan	-	6.3	-	-	-	-	-	0.3	15.2
8-Jan	-	5.8	-	-	-	-	-	0.3	17.6
9-Jan	-	6.0	-	-	-	-	-	0.4	16.9
10-Jan	-	5.3	-	-	-	-	-	0.3	18.8
11-Jan	-	5.1	-	-	-	-	-	0.3	21.1
12-Jan	-	2.5	-	-	-	-	-	0.3	22.4
13-Jan	-	6.0	-	-	-	-	-	0.2	18.4
14-Jan	-	6.1	-	-	-	-	-	0.2	18.9
15-Jan	-	5.3	-	-	-	-	-	0.2	22.0
16-Jan	-	5.9	-	-	-	-	-	0.3	16.3
17-Jan	-	-	-	-	-	-	-	-	-
18-Jan	-	5.2	-	-	-	-	-	0.2	17.2
19-Jan	-	5.6	-	-	-	-	-	0.2	23.4
20-Jan	-	6.6	-	-	-	-	-	0.3	21.0
21-Jan	-	7.0	-	-	-	-	-	0.2	18.8
22-Jan	-	-	-	-	-	-	-	-	-
23-Jan	-	4.2/0.9	-	-	-	-	-	0.2	8.7
24-Jan	-	0.8	-	-	-	-	-	0.1	6.1
25-Jan	-	0.5	-	-	-	-	-	0.1	11.9
26-Jan	-	0.8	-	-	-	-	-	0.1	13.3
27-Jan	-	0.8	-	-	-	-	-	0.2	12.2
28-Jan	-	0.9	-	-	-	-	-	0.2	11.5
29-Jan	1.6	0.8	-	0.1*	0.1*	0.1*	-	0.2	10.7
30-Jan	-	0.9	-	-	-	-	-	0.2	8.6

DRAFT

Date	Flowrate		pH							T						
	AS-Effl.	Reactor	AS-Infl. (A)	AS-Effl. (BS-C)	R-Infl. (C)	R-25% (D)	R-50% (E)	R-75% (F)	R-Effl. (G)	AS-Infl. (A)	AS-Effl. (BS-C)	R-Infl. (C)	R-25% (D)	R-50% (E)	R-75% (F)	R-Effl. (G)
	gpm	gpm								°C	°C	°C	°C	°C	°C	°C
31-Jan	25.8	29.1	-	-	7.33	-	-	-	7.97	-	-	18.9	-	-	-	18.9
1-Feb	25.9	28.9	-	-	7.19	7.96	7.76	7.87	7.86	-	-	19.0	17.9	17.6	17.9	18.5
2-Feb	25.0	28.8	-	7.35	7.41	8.02	7.93	7.80	7.93	-	19.1	19.2	18.0	18.0	18.0	19.1
3-Feb	24.2	30.8	-	7.27	7.37	7.95	7.9	7.81	7.82	-	19.0	19.0	17.7	17.8	17.8	46.9
4-Feb	26.4	29.2	-	7.20	7.27	7.87	7.61	7.70	7.71	-	19.0	19.2	19.2#	19.2#	19.2#	19.1
5-Feb	25.1	30.7	-	7.44	7.47	-	-	-	7.83	-	18.8	18.9	-	-	-	18.8
6-Feb	24.9	29.0	-	7.08	7.20	7.88	7.69	7.67	7.69	-	18.9#	19.2#	19#	19#	19#	18.9#
7-Feb	24.5	30.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Feb	14.0	30.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Feb	14/20	32.1	-	-	7.68	-	-	-	7.98	-	-	19.3#	19.3#	19.4#	19.4#	19.4#
12-Feb	20.6/25.2	32.2	-	-	7.58	7.92	7.78	7.90	7.85	-	-	19.0#	19.2#	19.2#	19.1#	19.1#
13-Feb	25.1	29.8	-	7.27	7.35	7.99	7.75	7.85	7.85	-	19.1	19.3#	19.3#	19.3#	19.3#	19.3#
14-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Feb	25.2	29.0	-	6.92	7.13	7.65	7.35	7.41	7.36	-	18.8	18.9#	19#	19.1#	19.1#	19.0#
16-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Feb	25.2	30.1	-	7.50	7.59	8.03	7.81	7.86	7.87	-	19.2	19.2#	19.3#	19.4#	19.3#	19.4#
18-Feb	25.6	29.0	-	7.18	7.24	7.90	7.65	7.72	7.69	-	18.9	19.2#	19.2#	19.3#	19.2#	19.3#
19-Feb	25.1	30.8	-	6.99	7.11	-	-	-	7.37	-	18.8	18.8#	-	-	-	18.8#
20-Feb	25.5	30.8	-	7.14	7.17	7.63	7.40	7.49	7.57	-	19.1	19.3#	19.3#	19.3#	19.3#	19.2#
21-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Feb	25.0	30.5	-	6.93	6.95	-	-	-	7.20	-	16.7	16.7	-	-	-	16.3
24-Feb	25.0	30.0	-	7.19	7.25	-	-	-	7.65	-	19.0	19.3#	19.3#	19.3#	19.3#	19.2#
25-Feb	25.0	30.0	-	7.02	7.04	-	-	-	7.39	-	19.1	19.3#	19.3#	19.3#	19.3#	19.2#
26-Feb	24.9	29.2	-	7.23	7.28	-	-	-	7.78	-	19.1	19.20	-	-	-	19.20
27-Feb	25.0	29.8	-	7.04	7.16	-	-	-	8.05	-	19.3	19.3#	19.3#	19.3#	19.3#	19.3#
28-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Mar	25.5	29.0	-	7.15	7.29	-	-	-	8.22	-	20.0	19.4#	19.4#	19.5#	19.5#	19.5#
2-Mar	25.3	30.0	-	7.24	7.35	-	-	-	8.30	-	19.4	19.4#	19.4#	19.4#	19.4#	19.4#
3-Mar	24.5	30.6	-	7.17	7.23	-	-	-	8.19	-	19.6	19.3#	19.3#	19.4#	19.4#	19.4#
4-Mar	25.8	29.8	-	7.12	7.17	-	-	-	8.19	-	19.5	19.5	-	-	-	19.6
5-Mar	24.8	29.4	-	7.20	7.30	-	-	-	8.30	-	18.6	18.8	-	-	-	18.9
6-Mar	25.0	30.0	-	7.21	7.32	-	-	-	8.34	-	19.1	19.2#	19.2#	19.2#	19.2#	19.2#
7-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Mar	26.1	28.2	-	-	7.17	-	-	-	7.91	-	-	19.4#	-	-	-	19.5#
9-Mar	26.6	28.0	-	7.24	7.39	-	-	-	8.20	-	19.4	19.6#	19.6#	19.6#	19.6#	19.6#
10-Mar	25.5	31.2	-	7.22	7.35	-	-	-	8.19	-	19.9	19.8#	19.8#	19.8#	19.8#	19.8#
11-Mar	25.0	29.9	-	7.20	7.31	-	-	-	8.02	-	19.9	19.8#	19.8#	19.8#	19.9#	19.8#
12-Mar	25.4	28.4	-	7.15	7.25	-	-	-	7.93	-	19.8	19.7#	19.7#	19.7#	19.7#	19.7#
13-Mar	25.0	30.5	-	7.05	7.16	7.9	7.9	7.9	7.95	-	19.4	19.6#	19.6#	19.6#	19.6#	19.6#

Date	ORP							D.O.								Ethanol
	AS-Infl. (A)	AS-Effl. (BS-C)	R-Infl. (C)	R-25% (D)	R-50% (E)	R-75% (F)	R-Effl. (G)	Wet/AS Effl. (BS-C)	R-Infl.-inline (C)	R-Infl. (C)	R-25% (D)	R-50% (E)	R-75% (F)	R-Effl. (G)	R-Effl.-inline (G)	Flowrate
	mV	mV	mV	mV	mV	mV	mV	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ml/min
31-Jan	-	-	-201.6	-	-	-	-286.2	-	0.7	-	-	-	-	-	0.2	1.0
1-Feb	-	-	-226.0	-264.5	-274.2	-263.2	-304.2	-	1.2	-	0.6	1.0	1.5	-	0.2	9.6
2-Feb	-	-100.2	-243.8	-273.8	-279.0	-280.1	-310.0	-	0.7	0.5*	0.1*	0.1*	0.06*	0.06*	0.3	7.2
3-Feb	-	-	-253.9	-260.5	-240.3	-320.0	-323.0	-	0.5	0.5*	0.1*	0.1*	0.06*	0.06*	0.3	9.3
4-Feb	-	106.0	-249.5	-242.5	-252.0	-276.5	-318.0	1.7	0.6	-	.12*	0.1*	0.1*	-	0.3	7.7
5-Feb	-	84.3	-231.5	-	-	-	-308.7	1.7	1.0	-	-	-	-	-	0.3	8.4
6-Feb	-	-33.5	-241.0	-249.9	-292.0	-267.0	-314.1	1.3	1.0	.35*	0.08*	0.06*	0.06*	.11*	0.4	9.8
7-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.6
8-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Feb	-	-	-	-	-	-	-	-	1.3	-	-	-	-	-	3.0	-
11-Feb	-	-	-313.9	-	-	-	-318.1	-	0.6	.14*	0.09*	0.06*	0.06*	0.07*	0.5	-
12-Feb	-	-	-286.8	-311.0	-322.8	-247.4	-328.2	-	0.7	0.14*	0.09*	0.07*	0.06*	0.06*	0.3	5.9
13-Feb	-	81.0	-259.4	-309.6	-325.8	-265.5	-317.1	-	0.9	0.43*	0.20*	0.10*	0.10*	0.12*	0.4	5.9
14-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-Feb	-	48.9	-191.3	-185.2	-265.1	-270.5	-273.6	1.3	0.8	0.13*	0.1*	0.09*	0.09*	0.08*	0.4	9.4
16-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-Feb	-	-77.3	-206.9	-219.5	-274.7	-270.8	-298.5	-	0.9	.6*	.18*	.15*	.15*	.2*	0.5	7.3
18-Feb	-	-87.2	-235.2	-220.0	-278.6	-250.8	-314.5	-	0.9	.7*	.28*	.17*	.15*	.22*	0.4	9.9
19-Feb	-	-82.7	-230.5	-	-	-	-290.5	-	0.8	-	-	-	-	-	0.4	6.7
20-Feb	-	-29.6	-244.9	-288.0	-306.5	-257.7	-265.1	-	0.9	.45*	.18*	.14*	.15*	.22*	0.4	10.6
21-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Feb	-	96.0	-229.6	-	-	-	-284.5	-	1.2	-	-	-	-	-	0.5	-
24-Feb	-	108.1	-230.3	-	-	-	-285.0	1.2	0.9	.35*	.17*	.13*	.13*	.13*	0.5	8.4
25-Feb	-	75.4	-238.9	-	-	-	-294.0	1.3	0.9	.52*	.18*	.12*	.12*	.14*	0.4	7.6
26-Feb	-	34.3	-217.8	-	-	-	-281.0	1.7	0.8	-	-	-	-	.11*	0.0	7.8
27-Feb	-	122.0	-219.5	-	-	-	-287.0	1.10	0.9	.31*	.1*	.06*	.06*	.05*	0.1	5.8
28-Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Mar	-	136.5	-104.0	-	-	-	-167.4	1.1	0.8	.4*	.14*	.09*	.09*	.1*	0.1	5.5
2-Mar	-	116.7	-89.0	-	-	-	-155.0	-	0.9	.34*	.17*	.1*	.1*	.11*	0.1	5.4
3-Mar	-	107.0	-87.0	-	-	-	-157.7	-	0.8	.5*	.16*	.11*	.11*	.1*	0.0	5.4
4-Mar	-	10.2	-91.2	-	-	-	-161.1	-	0.9	-	-	-	-	-	0.1	5.5
5-Mar	-	108.1	-102.7	-	-	-	-148.1	-	0.7	-	-	-	-	-	0.1	6.4
6-Mar	-	113.6	-102.4	-	-	-	-184.7	1.1	1.0	.45*	.14*	.1*	.1*	.1*	0.1	4.9
7-Mar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Mar	-	-	-92.7	-	-	-	-170.6	-	0.7	.32*	-	-	-	.17*	0.1	7.2
9-Mar	-	-1.7	-121.4	-	-	-	-179.5	1.1	0.9	.42*	.12*	.1*	.1*	.09*	0.1	6.4
10-Mar	-	-32.0	-132.0	-	-	-	-201.1	1.0	0.7	.38*	.15*	.07*	.07*	.06*	0.1	5.5
11-Mar	-	19.0	-143.0	-	-	-	-201.1	1.1	0.9	.4*	.11*	.06*	.1*	.06*	0.1	9.4
12-Mar	-	-19.5	-164.0	-	-	-	-221.5	1.2	0.8	.5*	.09*	.08*	.06*	.07*	0.1	8.3
13-Mar	-	-51.1	-175.2	-185.7	-194.1	-217.7	-227.5	0.9	0.8	.22*	.11*	.06*	.09*	.05*	0.1	7.8

* = DO measurements taken inside reactor not at sample ports, all other non-starred, non-inline readings taken with hand held at sample port

\# = temperature recorded with ysi DO probe inside reactor not at sample ports, all others measured with handheld at sample ports

DRAFT

Bioreactor D.O. Profiles

Date		1/22/98	1/22/98	1/25/98	1/29/98
Percent Recirculated Water		33%	33%	33%	17%
		AS ON		AS OFF	
	Feet	before stir (mg/L)	after stir (mg/L)	(mg/L)	
Reactor Bottom	0'	5	5.4	0.50	0.65
	1'	5	2.9	0.10	0.20
	2'	4.3	2.5	0.10	0.12
1/4 h	3'	2.5	1.3	0.10	0.10
	4'	2.2	0.7	0.10	0.08
	5'	1.4	0.2	0.10	0.08
	6'	0.4	0.1	0.10	0.08
1/2 h	7'	0.35	0.1	0.10	0.08
	8'	0.3	0.1	0.10	0.08
	9'	0.2	0.1	0.10	0.08
	10'	0.2	0.1	0.10	0.08
3/4 h	11'	0.1	0.1	0.10	0.08
	12'	0.1	0.1	0.10	0.08
	13'	0.1	0.1	0.10	0.08
	14'	-	-	0.10	0.08
Reactor Top	15'	-	-	-	-